Cira et al v. Henry County

EXHIBIT "C"

United States District Court
Northern District of Georgia, Atlanta Division

Cira et al Plaintiff, v. City of Hampton, County of Henry et al Defendants.	No. 1:21-cv-01999-TCB

EXPERT REPORT OF MARK KROLL, PhD, FACC, FHRS, FIEEE, FAIMBE

This report summarizes my analysis and findings and includes a statement of my opinions. The report also includes data and other information considered by me in forming my opinions and sets out my qualifications (including my CV which is an integral part of this report).

Mark Kroll, PhD, FACC, FHRS, FAIMBE, FIEEE 22 April 2022

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Glossary & Abbreviations

1. *Conducted electrical weapon (CEW): handheld probe-launching electrical weapon*
2. *To control electronically: to successfully use a CEW in probe mode*
3. *Electronic control: the goal of controlling electronically*
4. *Deployment: launch of probes*
5. *Electrocution: death from electricity*
6. *ARD: Arrest-related death*

Brief Summary of Qualifications

I am a Biomedical scientist with a primary specialty in bioelectricity and a secondary specialty in biomechanics (with a focus on the biomechanics of ventilation).

Regarding bioelectricity, I have invested most of my career researching and developing electrical devices to diagnose and treat disease. The primary focus is the effect of electrical shocks on the human body. This involves researching, lecturing, and publishing on electric shocks and their effects on the human body.

Regarding the biomechanics of ventilation, my scientific colleagues and I have researched and published on fundamental questions surrounding breathing, ventilation, and respiration during restraint. This includes several peer-papers and Medline-indexed letters in respected forensic-pathology journals.[1-6] This research has also led to paid training for the New York state attorney general's office on how to investigate arrest-related deaths and several media interviews.

I have lectured throughout Europe, South America, and Asia (in 35 countries) as well as at many of the major universities and medical centers of the United States. Usually, the typical audience member is a cardiologist, medical examiner, or forensic pathologist. With over 380 issued U. S. patents and numerous pending and international patents, I currently hold the most patents on implantable medical devices of anyone in the world. Over 1 million people have had devices with some of these patented features in their chest, monitoring every heartbeat. http://bme.umn.edu/people/adjunct/kroll.html.

In 2010 was awarded the Career Achievement Award by the Engineering in Medicine and Biology Society (EMBS) of the Institute of Electrical and Electronics Engineers (IEEE) which is at the most prestigious award level internationally in Biomedical Engineering.
http://tc-therapeutic-systems.embs.org/whatsnew/index.html

Believed to be the only individual to receive the high "Fellow" honor from both Cardiology and Biomedical societies. To wit:

1997 Fellow, American College of Cardiology
2009 Fellow, Heart Rhythm Society
2011 Fellow, IEEE Engineering in Medicine and Biology Society
2013 Fellow, American Institute for Medical and Biological Engineering

Author of over 200 abstracts, papers, and book chapters and also the coeditor of 4 books including the only 2 scientific treatises on Conducted Electrical Weapons (CEW):

1. TASER® Conducted Electrical Weapons: Physiology, Pathology and Law. Springer-Kluwer 2009.

2. Atlas of Conducted Electrical Weapon Wounds and Forensic Analysis: Springer-Kluwer 2012.

Directly relevant publications include over 100 papers, books, book chapters, indexed letters on CEWs and arrest-related death (ARD), and numerous scientific meeting abstracts. For more details please see CV at:
https://www.dropbox.com/sh/wju0hu6q3ca62xx/AAAlzTlLbKbxu5m34AsMfCrYa?dl=0

There have also been many presentations on CEWs to scientific, medical, pathology, as well as law enforcement, audiences. These include: 2007 American Academy of Forensic Science (AAFS) conference major presentation in San Antonio, Texas and the 2007 BEMS (Bio-electromagnetic Society) meeting Plenary Address in Kanazawa, Japan.

1. Major invited lecture at the 2006 NAME (National Association of Medical Examiners) conference in San Antonio, Texas.
2. Advanced Death Investigation Course of St. Louis University (2007) as faculty lecturer to full audience.
3. Faculty lecturer to full audience at Institute for the Prevention of In-Custody Death Conferences (2006 and 2007), Las Vegas, Nevada.
4. Chair of special session on TASER CEW at 2006 Cardiostim meeting in Nice, France.
5. Guest lecture to U.S. Military on CEW in 2006.
6. "Presenting Rhythm in Sudden Custodial Deaths After Use of TASER® Electronic Control Device," was presented at the 2008 scientific conference of the Heart Rhythm Society.
7. "Can Electrical-Conductive Weapons (TASER®) alter the functional integrity of pacemakers and defibrillators and cause rapid myocardial capture?" was presented at the 2008 scientific conference of the Heart Rhythm Society.
8. "Weight-Adjusted Meta-Analysis of Fibrillation Risk From TASER® Conducted Electrical Weapons" presented at the 2009 AAFS conference.
9. "Meta-Analysis of Fibrillation Risk From TASER® Conducted Electrical Weapons as a Function of Body Mass" presented at the 2009 scientific conference of the Heart Rhythm Society.
10. Oral presentation at the 2014 NAME (National Association of Medical Examiners) conference in Portland, Oregon.
11. Pathophysiological Aspects of Electroshock Weapons. University of Salzburg Electroshock Weapon Symposium. Salzburg, Austria. July 2015.
12. Real and Imagined Risk of Electrical Weapons. University of Salzburg Electroshock Weapon Symposium. Salzburg, Austria. Dec 2016.
13. Benefits vs. Real and Perceived Risks of Handheld Electrical Weapons. European Non-Lethal Weapons Conference, Brussels, May 2019.
14. Arrest-Related Deaths: Managing Your Medical Examiner. Lexipol WebCast 20 June 2019: https://info.lexipol.com/webinar-arrest-related-deaths

15. Defending Non-firearm Arrest-Related Death Cases. International Municipal Lawyers Association Conference. Washington, DC. 24 April 2020.
16. Investigating Non-firearm Arrest-Related Death Cases. NY State Office of Attorney General, Albany NY. March 2021.

In addition to the major addresses above, there have been lectures and presentations at the U.S. Department of Justice (2007), AAFS (2006), and BEMS (2006) regarding TASER CEWs.

I have deployed and discharged TASER CEWs numerous times and have personally experienced a TASER® X26 CEW probe deployment discharge to the center of my chest.

Relevant Committees and Boards:

1. International Electrotechnical Commission (IEC) (Geneva, Switzerland) TC64 MT4 Committee. This committee is the top international authority for setting the international electrical safety limits for electrocution and other electrical dangers.
2. American Society for Testing and Materials) ASTM, Committee: E54 Homeland Security Applications, Subcommittee: E54.08 Operational Equipment, including Less-Lethal Task Group, including: ASTM (draft) Standard WK61808 New Test Method for Correct Performance of Less-Lethal Electroshock Weapons Used by Law Enforcement and Corrections.
3. Axon Enterprise, Inc. (Axon né TASER), corporate and also Scientific and Medical Advisory Board.
4. ANSI (American National Standards Institute) CPLSO standards committee on electrical weapons.

Courtroom testimony in U.S., Australia, and Canada, and retained expert in the United Kingdom and France. I also have significant research, publications, and testimony in the areas of resuscitation, ARDs (arrest-related death), prone restraint, and biomechanics.

Brief Summary of Important Background Facts

1. Law enforcement officers basically have 3 choices for restraint in the field: electrical (aka electronic), mechanical, and chemical. I do *not* do research nor opine on chemical restraint which usually involves the administration of ketamine.[7-11]

2. Major studies sponsored by the US DOJ show that use of electronic control reduces the suspect injury rate by at least 2/3 compared to alternative force options, including hands-on physical force.[12,13] The MacDonald study covered 12 USA law enforcement agencies and 24,380 uses of force.[12] They found that the CEW reduced subject injury by 65%. Taylor et al analyzed data from 13 USA agencies including 16,918 uses of force and described a 78% reduction in injuries requiring medical attention.[13] In other words, the peer-reviewed literature shows that the use of other control techniques will at least triple (3x) the injury rate compared to the use of a Conducted Electrical Weapon (CEW).

3. The X26E, X26P, and X2 CEWs used by the agencies involved here deliver a safe level of electrical current as specified by the Underwriters Laboratories (UL) and International Electric Fence standards.[14] In fact, they satisfy all relevant electrical safety standards.[15-17]

4. These CEWs delivers <1.8 W which satisfies the UL electric fence safety limit of an equivalent of 5 W and even the more conservative 2.5 W international limit.[18,19]

5. The CEWs Involved in this incident, all satisfy the ANSI CPLSO-17:2017 "Electrical Characteristics of ECDs and CEWs" standard.[20]

6. There are many reasons that modern policing has adopted prone restraint for handcuffing the uncooperative subject. These include: (1) best core control for kinesiological stability, (2) restriction of hip flexors to reduce subject metabolic demands (and acidosis) and protect officers from kicks,[21] (3) restriction of shoulder and elbow flexors to reduce metabolic demands and protect officers from punches,[21] (4) prevention of occipital head-banging injury and bites to officers, (5) officer tactical visual advantage to accelerate the cuffing process, and (6) better gas exchange as seen in COVID patients.[22-26]

7. The real-world field experience also strongly supports the safety of prone positioning for the immediate management of combative subjects *after* handcuffing. In total, 3 large prospective studies found zero (0) deaths in 4288 cases left in the prone position and a single (1) death in 3601 cases left in other positions after handcuffing.[27-29]

Brief Summary of Opinions in This Case

1. Mr. Rodriguez had a body-mass index of 41.8 kg/m^2 placing him in the "severe" obesity class. Since fat is largely an electrical insulator, this high BMI significantly reduced the effectiveness of the electrical weapons used.[30,31]

2. The use of electronic muscle control was very moderate being only 30 seconds out of the 761 seconds between the 1st trigger pull and the end of the last trigger pull for a muscle control burden of only 3.9%.

3. Mr. Rodriguez never had a probe near his heart, and this alone eliminates electrocution as a possible cause of death.

4. Mr. Rodriguez's severe obesity alone eliminates electrocution as a possible cause of death since even a probe directly over the heart would not have been able to deliver sufficient current to the heart.[32]

5. Mr. Rodriguez resisted for several minutes after the last trigger pull and this alone eliminates electrocution as a possible cause of death. With an electrocution, consciousness ceases within 13 ± 4 seconds in a person laying down.[33]

6. Mr. Rodriguez was never exposed to weight sufficient to compromise his breathing.

7. During an estimated 2:11 (min:sec) of video-confirmed full-prone restraint Mr. Rodriguez had a calculated weight force of about 73 lb. on his back. This is well below the 225 lb. prone weight demonstrated to be safe even with hog-tied subjects.[34]

8. The 73 lb on the back was well below the 400 lb. of prone weight required for ventilatory compromise from crowd-crush research.[35-37]

9. During this brief period of the prone restraint, Mr. Rodriguez was still able to yell which demonstrates ventilation.

10. There was no abdominal restriction and thus there was no compromise of diaphragmatic breathing.

11. There was never any significant force (such as a knee) on the abdomen. Even if we were to assume *hypothetically* that there had been force on the abdomen during the prone positioning, there was still in an insufficient time to cause compression asphyxia since that requires 4 minutes versus the slightly over 2 minutes in the prone position.

12. The officers in this incident demonstrated an unusual degree of caution regarding the placement of weight on the thorax. Instead, they placed weight on the thighs, legs, handcuffs, and leg shackles which does not compromise ventilation.

13. Electrocution is a standalone cause of death and does not combine with other trauma. Electrocution is not like a soup recipe where salt and pepper both contribute to the flavor. It does not "contribute" to other causes of death.[38] Thus, the electrical weapon usage did not *contribute* to this tragic death.

Timelines

Clock Drift Corrections

Table 1. X26E (Lewis) clock drift correction

Closest Clock Correction	3-Oct-19
Previous Clock Correction	15-Jan-19
Shown Time	14:39:18
Actual Time	14:29:13
Elapsed Days	261
Drift (min:sec). Positive = "fast"	0:10:05
Seconds of Drift	605
Drift Rate: Seconds per Day	2.32
Date of Incident	20-Sep-19
Closest Clock Correction	3-Oct-19
Days Elapsed from Correction	-13
Predicted Seconds of Drift	-30.1
Predicted Drift (min:sec) from closest post-incident correction	-0:00:30
Total Correction	0:09:35
Raw Time of 1st Trigger Pull	22:21:55
Predicted Actual Time Trigger Pull	22:12:20
(End time for old models, start time for new models)	

Table 2. X26P (Bowlden) clock drift correction

Previous Clock Correction	25-Jun-19
Shown Time	13:01:36
Actual Time	12:59:55
Elapsed Days	90
Drift (min:sec) Positive = "fast"	0:01:41
Seconds of Drift	101
Drift Rate: Seconds per Day	1.12
Date of Incident	20-Sep-19
Closest Clock Correction	23-Sep-19
Days Elapsed from Correction	-3
Predicted Seconds of Drift	-3.4
Predicted Drift (min:sec) from closest post-incident correction	-0:00:03
Total Correction	0:01:38
Raw Time of 1st Trigger Pull	22:21:55
Predicted Actual Time Trigger Pull	22:20:17
(End time for old models, start time for new models)	

Table 3. X2 (Phillips) clock drift correction

Closest Clock Correction	23-Sep-19
Previous Clock Correction	18-Oct-18
Shown Time	13:19:48
Actual Time	13:14:13
Elapsed Days	340
Drift (min:sec) Positive = "fast"	0:05:35
Seconds of Drift	335
Drift Rate: Seconds per Day	0.99
Date of Incident	20-Sep-19
Closest Clock Correction	23-Sep-19
Days Elapsed from Correction	-3
Predicted Seconds of Drift	-3.0
Predicted Drift (min:sec) from closest post-incident correction	-0:00:03
Total Correction	0:05:32
Raw Time of 1st Trigger Pull	22:24:27
Predicted Actual Time Trigger Pull	22:18:55
(End time for old models, start time for new models)	

Table 4. Drift alignment analysis

Item	Ofc	Lewis BWC #1 Time	Lewis Delta to Corrected CEW Download (s)	Corrected CEW Download	Raw Down-load	Cor-rection (Fast)
X26E TP #1	Lewis	22:11:52	17	22:12:09	22:21:49	0:09:40
X26E TP #2	Lewis	22:11:59	16	22:12:15	22:21:55	0:09:40
X26E TP #3	Lewis	22:12:16	16	22:12:32	22:22:12	0:09:40
X26E TP #4	Lewis	22:12:26	17	22:12:43	22:22:23	0:09:40
X26E TP #5	Lewis	22:12:57	17	22:13:14	22:22:54	0:09:40
X26E TP #6	Lewis	22:15:57	17	22:16:14	22:25:54	0:09:40
X26E TP #7	Lewis	22:16:24	17	22:16:41	22:26:21	0:09:40
X26P TP #1	Bowlden	22:16:13	20	22:16:33	22:18:11	0:01:38
X26P TP #2	Bowlden			22:16:54	22:18:32	0:01:38
X26P TP #3	Bowlden	22:17:19	21	22:17:40	22:19:18	0:01:38
X26P TP #4	Bowlden	22:17:23	20	22:17:43	22:19:21	0:01:38
X2 TP #1	Phillips	22:17:42	21	22:18:03	22:23:35	0:05:32
X2 TP #2	Phillips	22:17:49	20	22:18:09	22:23:41	0:05:32
X2 TP #3	Phillips	22:18:35	20	22:18:55	22:24:27	0:05:32
X2 TP #4	Phillips	22:18:44	20	22:19:04	22:24:36	0:05:32
X2 TP #5	Phillips	22:19:37	22	22:19:59	22:25:31	0:05:32
X2 TP #6	Phillips			22:20:38	22:26:10	0:05:32
X2 TP #7	Phillips			22:21:52	22:27:24	0:05:32

Actual Times of Trigger Pulls

1. X26E vs Lewis BWC 16.5 ± 0.41 s (mean ± standard deviation)
2. X26P vs Lewis BWC 20.3 ± 0.58 s
3. X2 vs Lewis BWC 20.6 ± 0.89 s

X26P vs X2 drifts are close by Student's T-test ($p = 0.51$)
X26E vs X2 drifts are different by Student's T-test ($p = 0.000001$)

There were several discernible trigger-pulls in the Lewis BWC and these were used for drift correlation. It is seen that the X2 and X26P offsets were statistically similar and these were then used for absolute time. This is consistent with the fact that both CEWs had their time correction done within 3 days of the incident whereas the X 26E time was adjusted 13 days later and hence had more opportunity for drift.

Thus, we can conclude that the X26E was running 4 seconds slow after correction. Also note that for this model the trigger pull time is the end rather than the start of the trigger pull and the 5-second durations have already been deducted. This then gives us the actual times shown in Table 5.

Table 5. Actual times of trigger pulls.

Trigger Pull	Ofc	Actual Time	Duration
X26E TP #1	Lewis	22:12:13	5
X26E TP #2	Lewis	22:12:19	5
X26E TP #3	Lewis	22:12:36	5
X26E TP #4	Lewis	22:12:47	5
X26E TP #5	Lewis	22:13:18	5
X26E TP #6	Lewis	22:16:18	5
X26E TP #7	Lewis	22:16:45	5
X26P TP #1	Bowlden	22:16:33	5
X26P TP #2	Bowlden	22:16:54	5
X26P TP #3	Bowlden	22:17:40	1
X26P TP #4	Bowlden	22:17:43	4
X2 TP #1	Phillips	22:18:03	5
X2 TP #2	Phillips	22:18:09	5
X2 TP #3	Phillips	22:18:55	5
X2 TP #4	Phillips	22:19:04	5
X2 TP #5	Phillips	22:19:59	1
X2 TP #6	Phillips	22:20:38	1
X2 TP #7	Phillips	22:21:52	2

Electrical Weapon Deployments

A. X26E (Ofc. Lewis)

The X26E does not feature pulse-graph storage and thus the current delivery must be ascertained from subject movement, testimony, and sound analysis.

Table 6. X26E Trigger Pulls

TP#	Ofc	Actual Time	Duration	Muscle Control (s)	Effect
#1	Lewis	22:12:13	5	5	Takedown (Lewis & Stroud BWC)
#2	Lewis	22:12:19	5	5	Lower body effect (Lewis BWC)
#3	Lewis	22:12:36	5	5	Lower body effect (Stroud BWC)
#4	Lewis	22:12:47	5	5	Lower body effect (Lewis BWC)
#5	Lewis	22:13:18	5	5	Lower body effect (Lewis BWC)
#6	Lewis	22:16:18	5	0	None (Bowlden & Phillips BWC)
#7	Lewis	22:16:45	5	0	None (Lewis BWC)

The initial X26E deployment was accurate with the top probe near the center back. Good muscle-control effect was seen with a clean takedown. There were 4 additional trigger pulls, which showed some effect on Rodriguez's lower body, while the officers were unsuccessful in persuading Rodriguez to roll over onto his stomach. Between 22:13:18 and 22:16:18 the connection was broken which typically happens when the subject is resisting on the ground. The last 2 trigger pulls of Officer Lewis delivered zero (0) current which he recognized when he said "I ain't got a good connection" at 22:16:59.

B. X26P (Ofc. Bowlden).

The X26P features pulse-graph storage and thus the current delivery can be ascertained directly.

For Q (charge) $\geq 60\ \mu C$ the impedance prediction equation is:[39]

$$Z = 4.94[V_{arc}/Q]^2 + 9.3\sqrt{V_{stim}} - 908 + 3.88Q$$

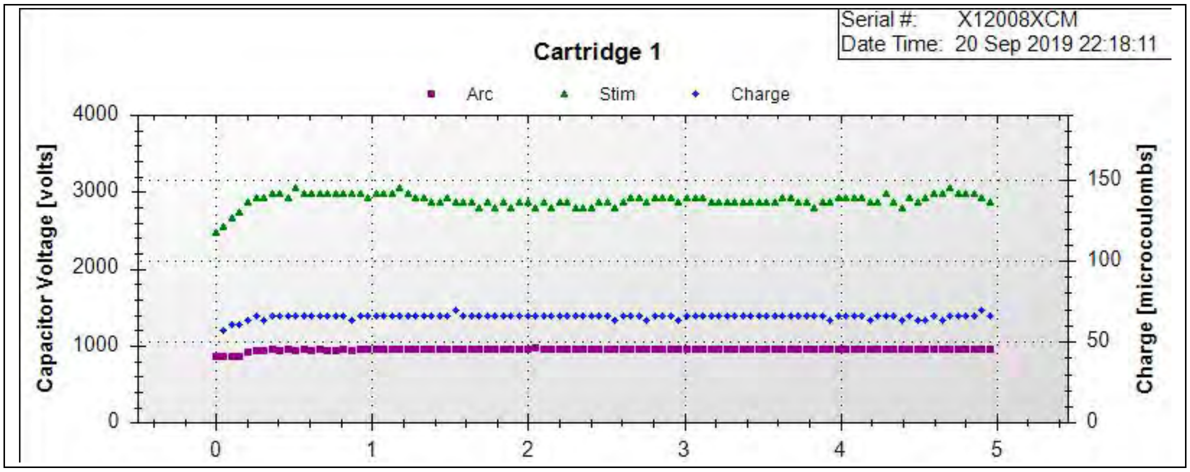

Figure 1. X26P pulse-graph 539.

The 1st X26P trigger pull appears to have achieved a reasonable connection with an estimated impedance of 744 Ω as shown in Figure 1. (Normal range is 470-690 Ω.[40]) However, the only video allowing a judgment of effect is the Phillips BWC and that shows minimal effect. This is minimal effect is often caused by an insufficient probe spread.[41]

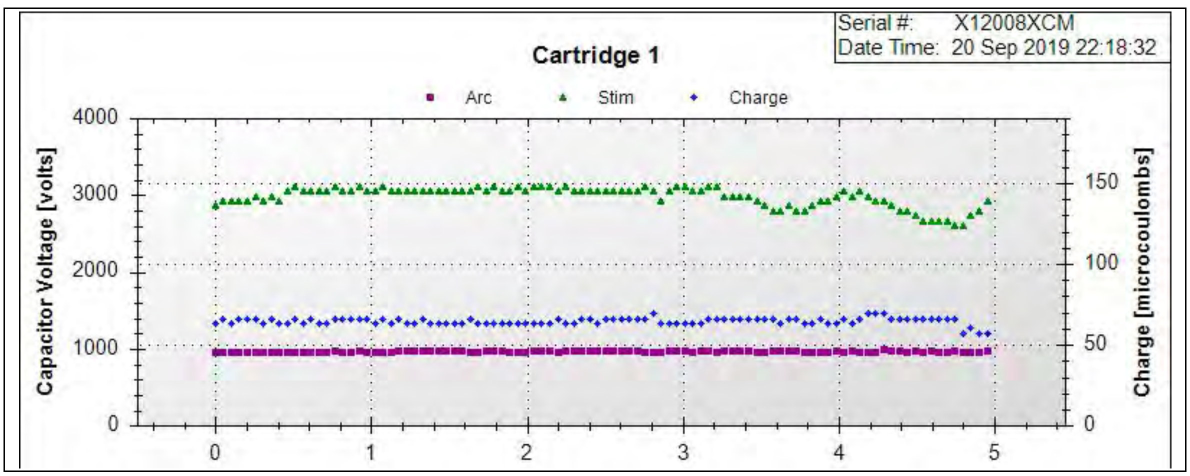

Figure 2. X26P pulse-graph 540.

The charge during the X26P trigger pull #2 had a high standard deviation as shown in Figure 1 (stdev = 2.2 μC) showing that the connection was broken. Ofc. Bowlden recalled, "When the subject continued to not comply I activated my Taser once more in an attempt to handcuff the subject under power but again due to the subject pushing himself down the road on his back and side he had disconnected one of leads causing the Taser to not have a good connection rendering it useless."

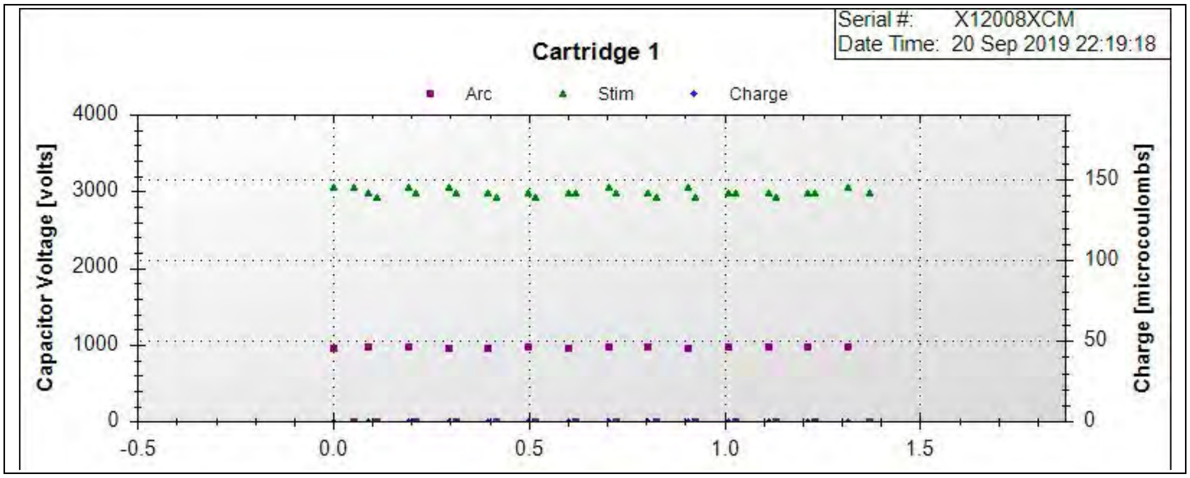

Figure 3. X26P pulse-graph 541.

The X26P trigger pull #3 delivered 0 charge as shown in Figure 3 and lasted 1.4 seconds.

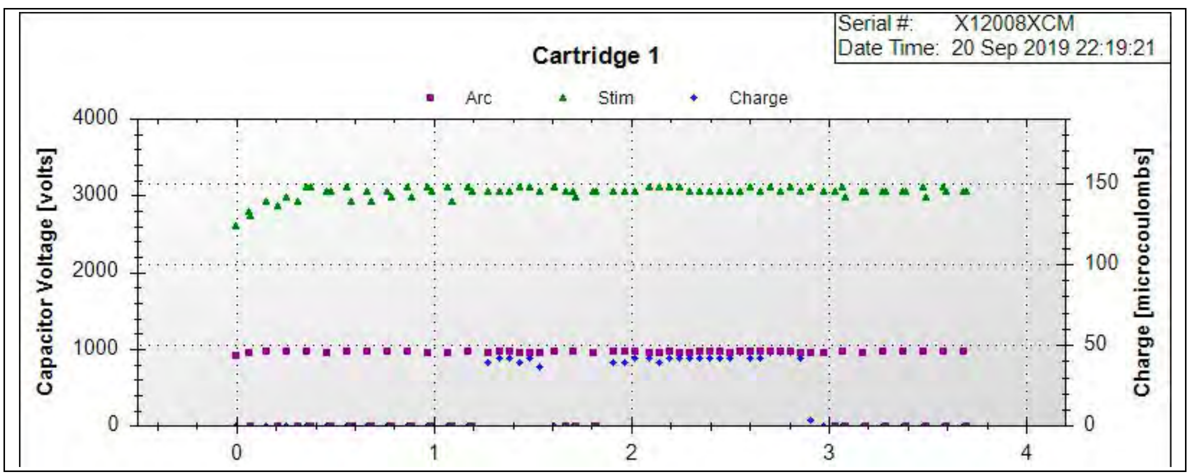

Figure 4. X26P pulse-graph 544.

Table 7. X26P Trigger Pulls

TP#	Actual Time	TP Duration (s)	Muscle Control	Vstim (V)	Varc (V)	Charge (μC)	Z predicted (Ω)
#1	22:16:33	5	5	2900	900	67	744
#2	22:16:54	5	0	3000	1000	67	arcing
#3	22:17:40	1	0			0	
#4	22:17:43	4	0	3000	unstable	0-40	

C. X2 (Ofc. Phillips).

Time 22:23:35 followed by 6-second delay before C2

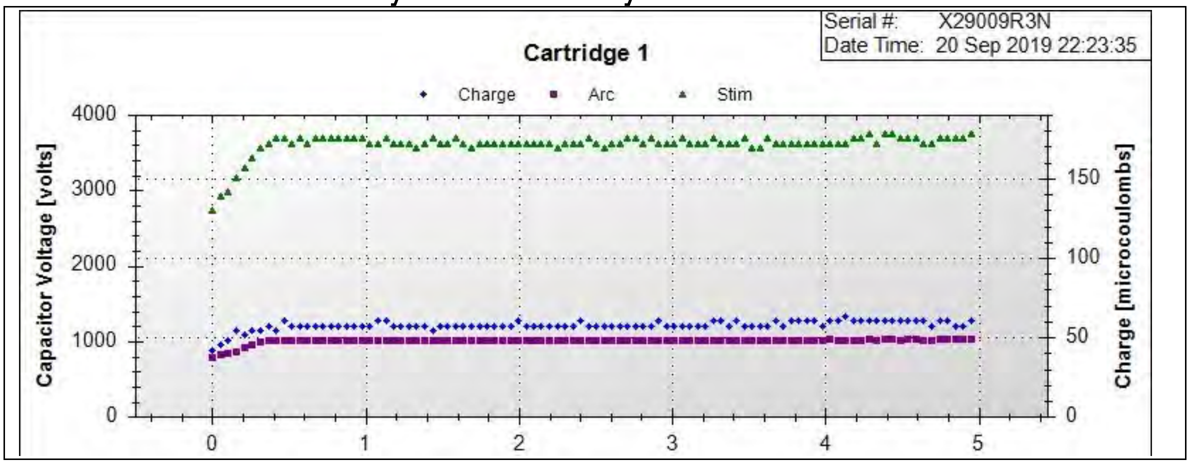

Figure 5. X2 pulse-graph 694.

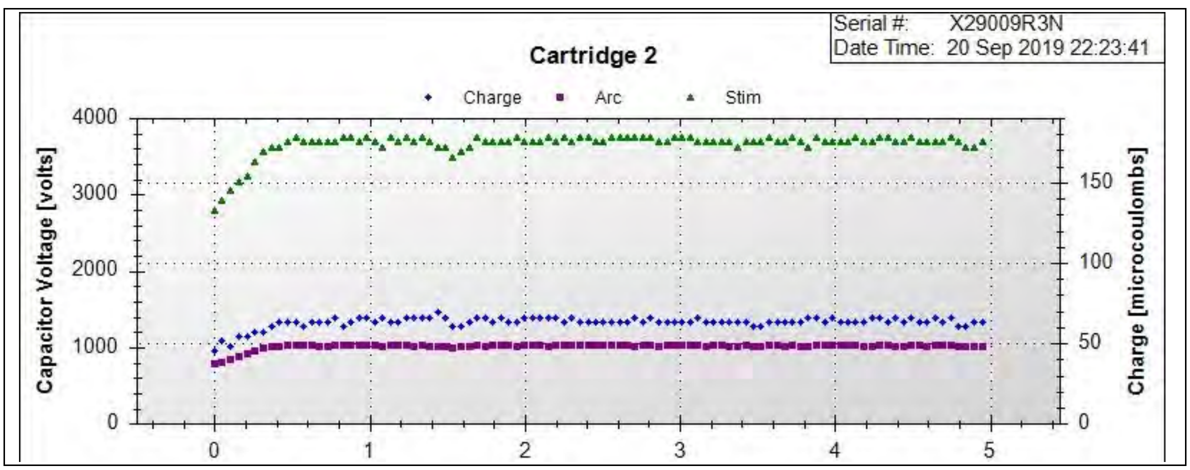

Figure 6. X2 pulse-graph 695.

Trigger Pull #3
Time 22:24:27

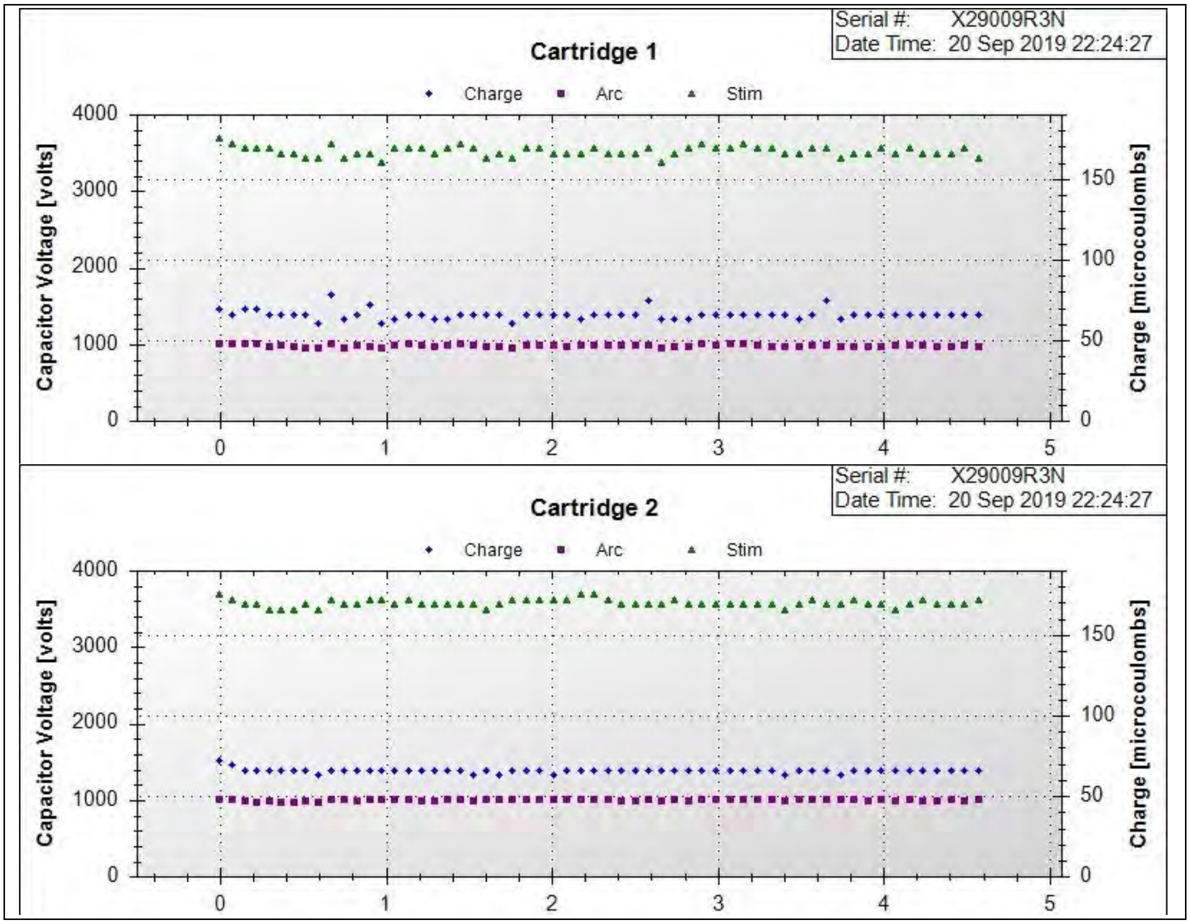

Figure 7. X2 pulse-graph pair 696.

Trigger Pull #4
Time 22:24:36

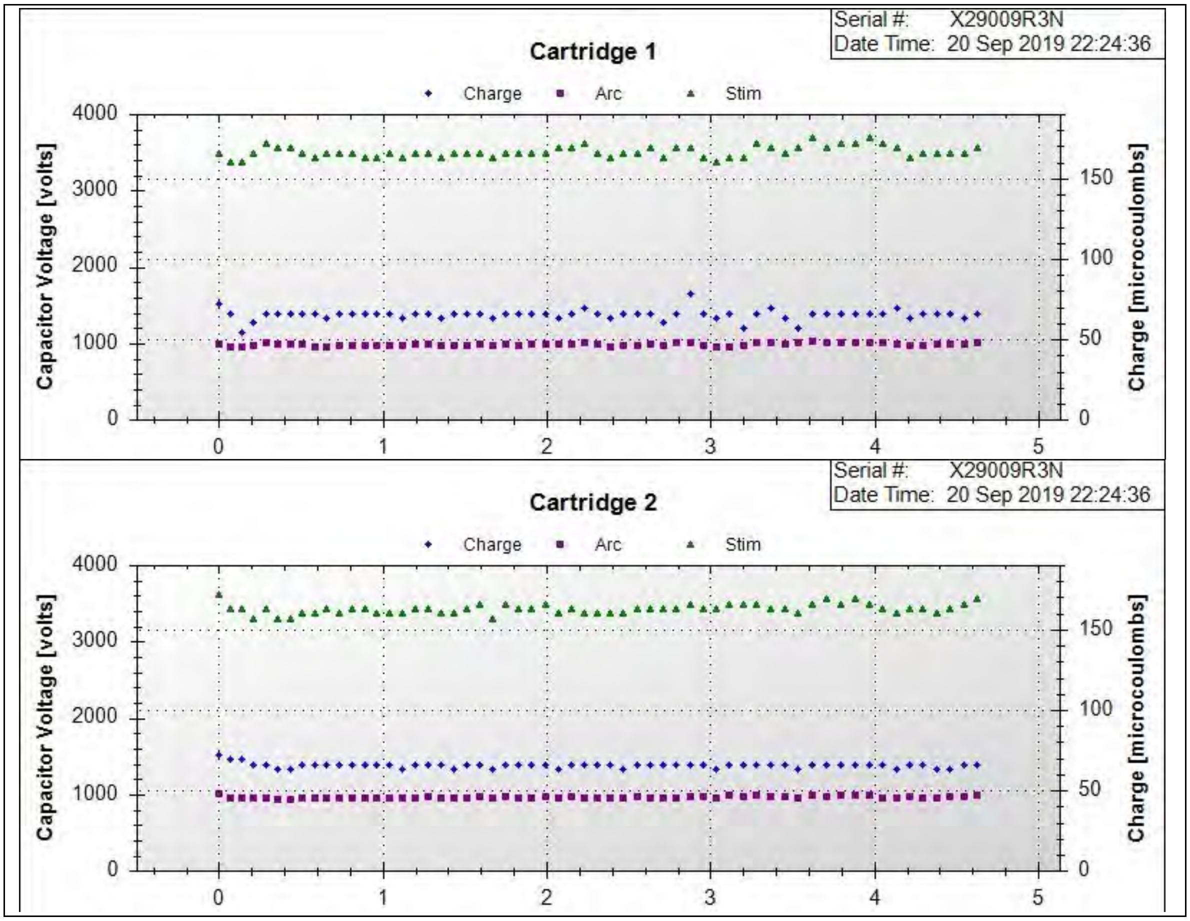

Figure 8. X2 pulse-graph pair 697.

Trigger Pull #5
Time 22:35:31

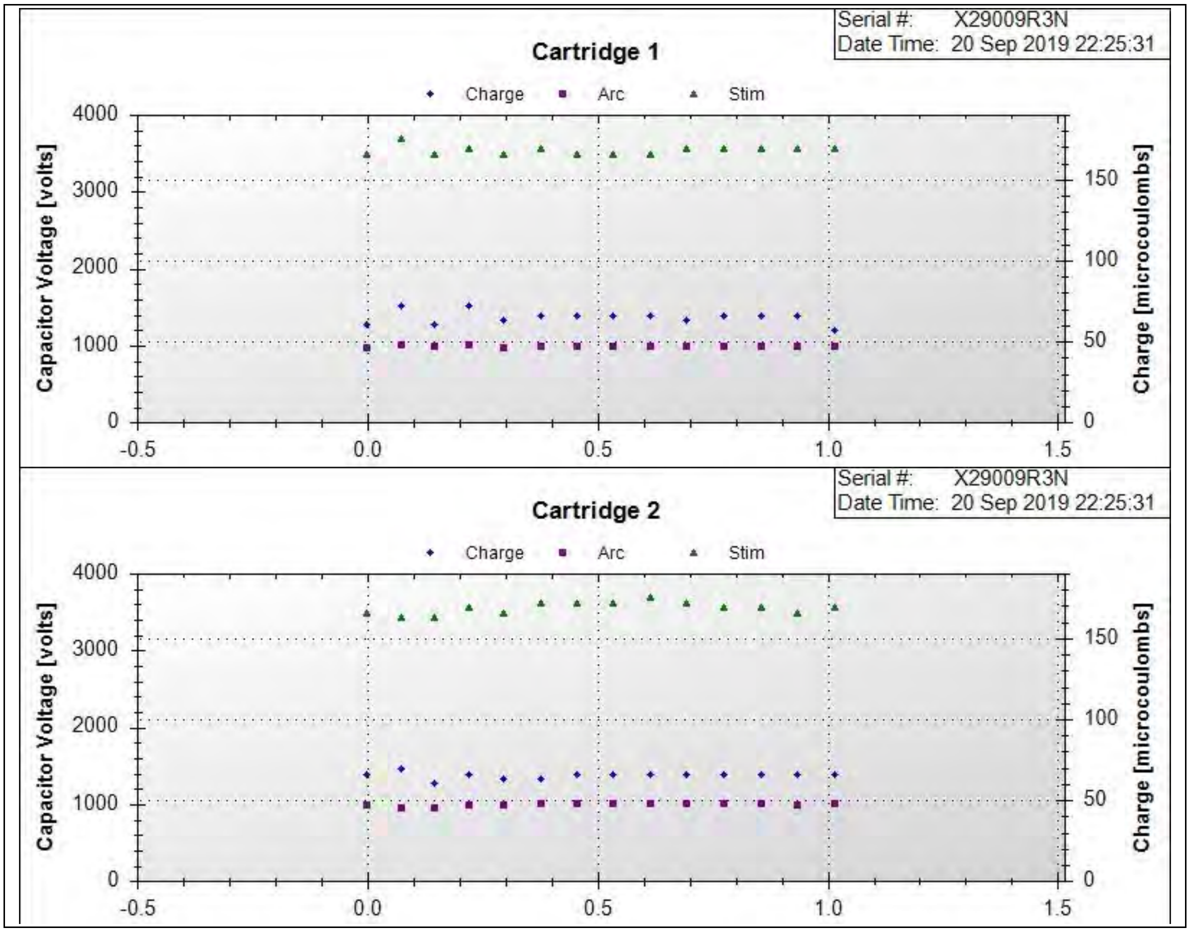

Figure 9. X2 pulse-graph pair 698.

Trigger Pull #6
22:26:10

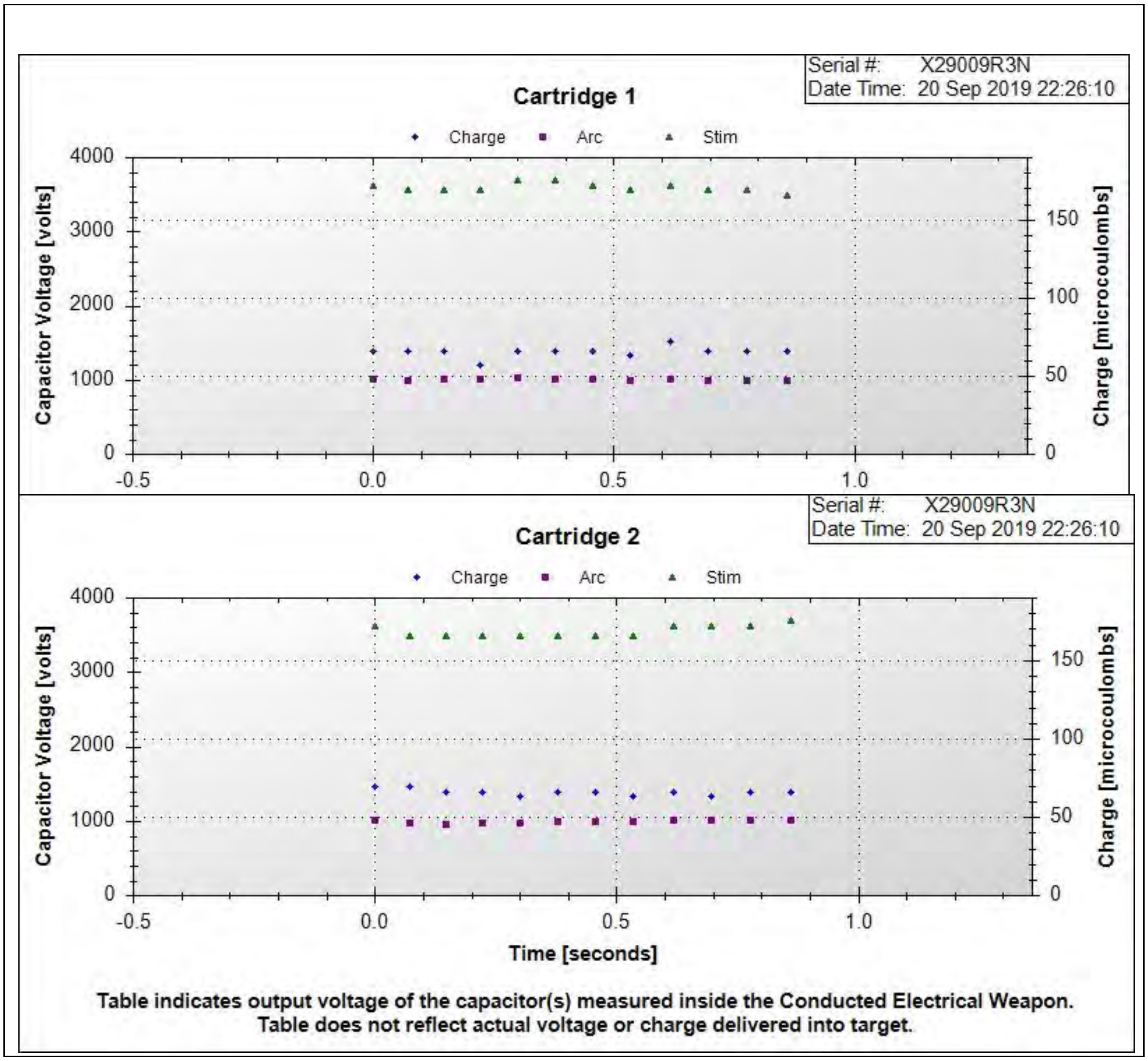

Figure 10. X2 pulse-graph pair 699.

Trigger Pull #7
Time: 22:27:24

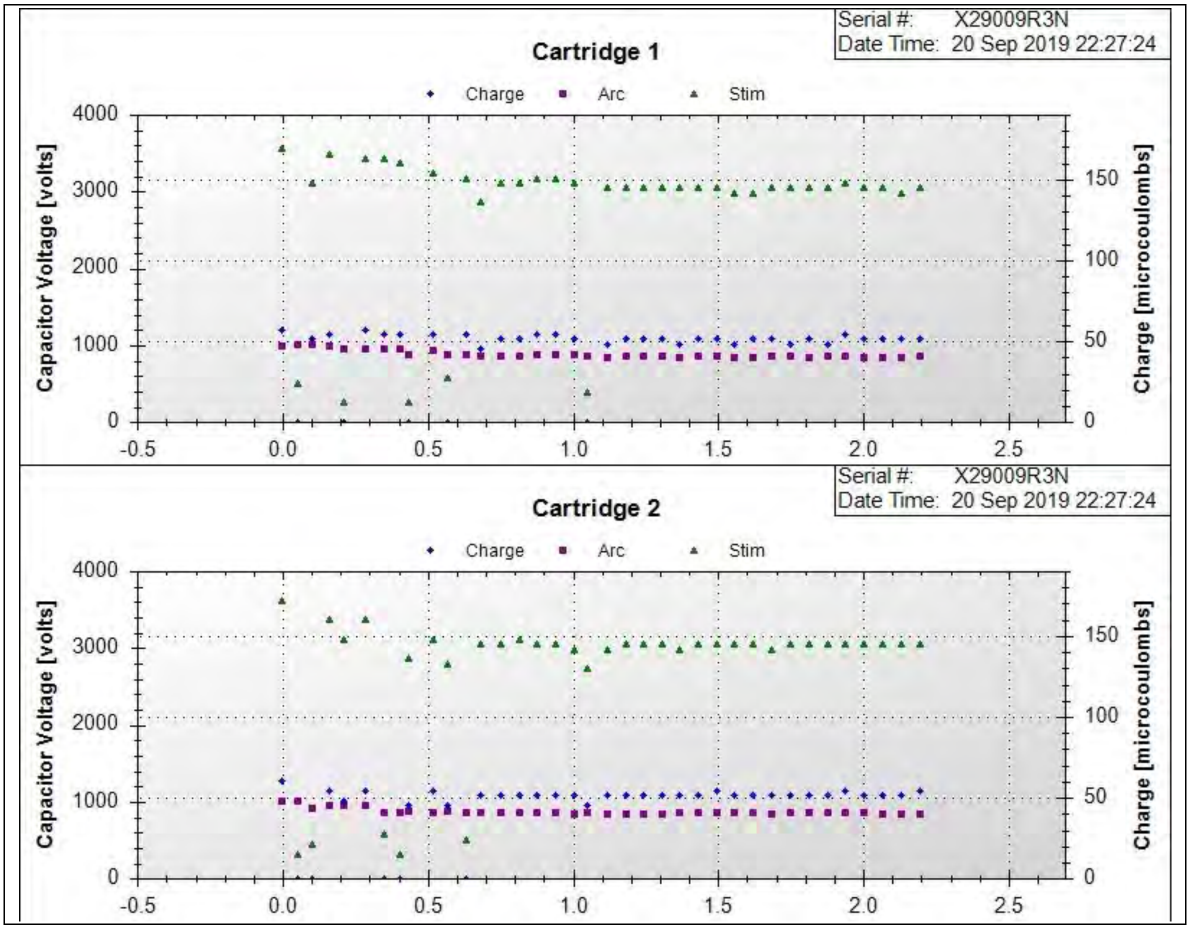

Figure 11. X2 pulse-graph pair 700.

For $Q \geq 60\ \mu C$ the X2 impedance prediction equation is:

$$Z = 4.94[V_{arc}/Q]^2 + 9.3\sqrt{V_{stim}} - 908\ \Omega$$

Table 8. X2 Trigger pulls (Ofc. Phillips)

TP#	Actual Time	TP Duration	Muscle Control (s)	Vstim (V)	Varc (V)	Charge (μC)	Z Calculated (Ω)	Stdev(μC)
#1	22:18:03	5	0	3700	1000	60	Arcing	2.17
#2	22:18:09	5	0	3700	1000	65	1079	1.89
#3 C1	22:18:55	5	0	3700	1000	67	Arcing	2.49
C2			0	3600	1000	67	1010	1.05
#4 C1	22:19:04	5	0	3500	1000	67	Arcing	2.33
C2			0	3500	1000	67	1003	1.38
#5	22:19:59	1	0					
#6	22:20:38	1	0					
#7	22:21:52	2	0					

Cartridge 1 failed to complete a connection and that is shown by the standard deviations of charge being greater than 2. Officer Phillips then deployed the 2nd cartridge but that landed in fat as seen by the impedance being greater than 1000 Ω. Thus, Ofc. Phillips was not able to achieve any muscle control. Note: in his report, Ofc. Phillips recalled that his first trigger pull (TP #1) was effective. However, both the Bowlden and Lewis videos show that Mr. Rodriguez was able to roll over during that trigger pull. Mr. Rodriguez was fairly quiescent during the first few seconds of that trigger pul and that probably lead Ofc. Phillips to believe that he was achieving neuromuscular incapacitation.

Mr. Rodriguez had a body-mass index of 41.8 kg/m^2 placing him in the "severe" obesity class. Since fat is largely an electrical insulator, this high BMI significantly reduced the effectiveness of the electrical weapons used.[30] Figure 18 shows his extreme abdominal obesity which explains why probes in his sides achieved minimal to zero muscular control.

All CEWs: Muscle Control Summary

Table 9. All CEWs: Muscle Control Summary

CEW	TP#	Ofc	Time	Duration	Muscle Control	Effect
X26E	#1	Lewis	22:12:13	5	5	takedown
X26E	#2	Lewis	22:12:19	5	5	lower body effect
X26E	#3	Lewis	22:12:36	5	5	lower body effect
X26E	#4	Lewis	22:12:47	5	5	lower body effect
X26E	#5	Lewis	22:13:18	5	5	lower body effect
X26E	#6	Lewis	22:16:18	5	0	no effect
X26E	#7	Lewis	22:16:45	5	0	no effect
X26P	#1	Bowlden	22:16:33	5	5	poor probe spread, some effect
X26P	#2	Bowlden	22:16:54	5	0	arcing
X26P	#3	Bowlden	22:17:40	1	0	drive-stun
X26P	#4	Bowlden	22:17:43	4	0	drive-stun
X2	#1	Phillips	22:18:03	5	0	arcing
X2	#2	Phillips	22:18:09	5	0	probe in fat
X2	#3 C1	Phillips	22:18:55	5	0	arcing
X2	C2	Phillips			0	probe in fat
X2	#4 C1	Phillips	22:19:04	5	0	arcing
X2	C2	Phillips			0	probe in fat
X2	#5	Phillips	22:19:59	1	0	drive-stun
X2	#6	Phillips	22:20:38	1	0	drive-stun
X2	#7	Phillips	22:21:52	2	0	drive-stun
		Totals:	0:09:39	74	30	

A Comment on the Baseball Rule

A rule-of-thumb — common in training — is that an officer should transition after 3 trigger pulls of an electrical weapon if control is not achieved. This is a reasonable guidance as such a lack of control would imply that the probes are lodged in fat, a probe has missed the body, or are too close together to achieve neuromuscular incapacitation.[41] The officer should then replace the cartridge with the single-shot X26E or X26P models or deploy a 2nd cartridge with the newer X2 or T7 units. Alternatively, an officer can transition to a drive-stun although this has very limited benefit. No one is suggesting a transition to a firearm or baton strikes.

Unfortunately, the "baseball" or "3-strikes" guidance has led to a misunderstanding that 3 trigger pulls from an electrical weapon are safe but that the 4th is somehow suddenly dangerous.[38] The 3-strikes analogy is obviously appealing in a country that loves baseball but what probably keeps this misinterpretation alive is the false intuition that electrical effects build up like poison. They do not; if an electrical current is strong enough to kill someone it generally does so in 1-2 seconds. No agencies have similar rules limiting uses-of-force

to 3 baton strikes or firearms to 3 rounds. This is ironic since baton strikes and bullets actually can cause cumulative damage.

Note that none of the officers in this case used their electrical weapons outside of this informal guidance. Officer Lewis was obtaining some muscle control up until trigger pull #5 at which point Ofc. Bowlden took over with electronic control. Officer Lewis did have a trigger pull #6 which was probably inadvertent due to many of the known factors present here.[42] When Ofc. Bowlden noticed that his 2nd trigger pull was having no effect, he transitioned to drive-stuns.

Officer Phillips noticed that his 1st deployment was having no effect so he immediately deployed his 2nd cartridge. (He was the only officer involved that had a 2-shot electrical weapon.) Thinking that he had a good connection and some muscle control effect, he delivered 2 more trigger pulls before he transitioned to drive-stuns. All of the officers in this case used their electrical weapons in substantial compliance with the common baseball-rule training.

Background on Prone Restraint:

There is a formerly popular media myth that the prone position interferes with breathing and gas exchange.[3,5] In fact, the opposite is true and this is reflected in many peer-reviewed scientific papers.[22-29,43-47] While there was never any scientific support for the anti-prone speculation, the hypothesis has been completely refuted by the attention given to this position saving so many lives of Covid patients.

Figure 12. The lay media is now recognizing the benefits of prone positioning.

For example, CNN had a story blaming an ARD on the prone position and then 8 ½ months later had a story explaining how the prone position saves lives. See Figure 13.

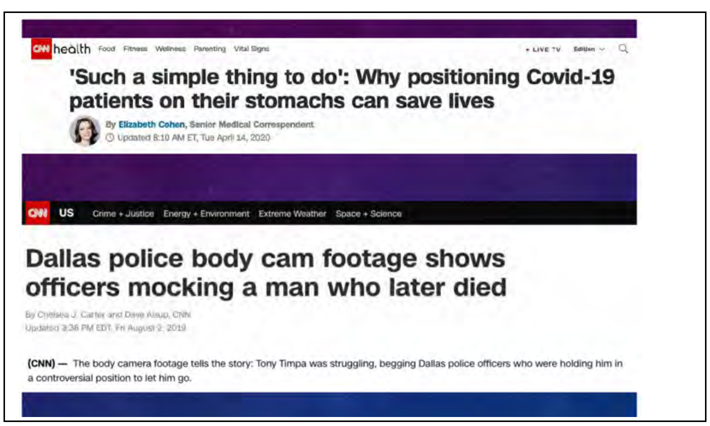

Figure 13. Media depiction of proning for police and physicians.

There are many reasons that modern policing has adopted prone restraint for handcuffing the uncooperative subject. These include: (1) best core control for kinesiological stability, (2) restriction of hip flexors to reduce subject metabolic demands (and acidosis) and protect officers from kicks,[21] (3) restriction of shoulder and elbow flexors to reduce metabolic demands and protect officers from punches,[21] (4) prevention of occipital head-banging injury and bites to officers, (5) officer tactical visual advantage to accelerate the cuffing process, and (6) better gas exchange as seen in COVID patients. [22-26]

The real-world field experience strongly supports the safety of prone positioning for the immediate management of combative subjects even after handcuffing. In total, 3 large prospective studies found zero (0) deaths in 4288 cases left in the prone position and a single (1) death in 3601 cases left in other positions after handcuffing. [27-29]

Compression or crush asphyxia has caused death from soft-drink (soda) vending machine tipping, building collapse, vehicle accidents, crowd collapse, and trench cave-ins.[35,48-57] True compression asphyxia, has been differentiated as "a form of suffocation where respiration is prevented by external pressure on the body."[50,58]

Published research has found no evidence of compression asphyxia in hogtied individuals with a static mass up to 102 kg (225 lbs) on the back.[34] However, numerous deaths from falling soda machines have been reported. [51-54]

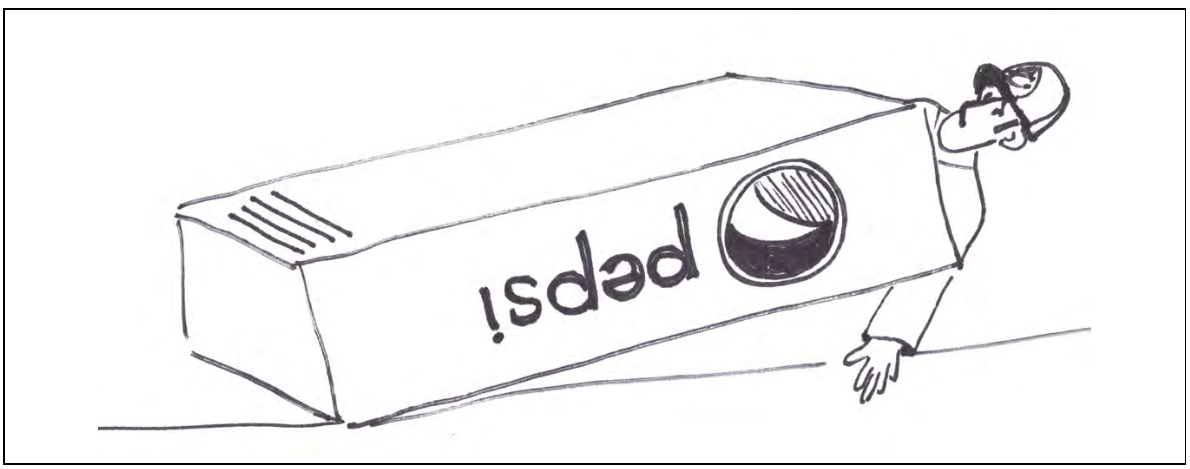

Figure 14. True compression deaths typically involve broken ribs and weights > 1000 lb.

Since a fully-loaded soda vending machine weighs up to 500 kg (1100 lbs), with most of the mass in the top, these deaths establish that an impact (falling) load of 500 kg can kill an adult human. Most of the published fatal chest compression cases involve the mass of a car or tractor (typically > 1000 kg) compressing the torso and hence they set a high upper bound on the mass required for ribcage failure. [50,59]

Figure 15. The human chest can handle a surprising amount of weight.

A biomechanical ribcage model shows that an adult male requires at least 572 ± 57 lbs of static chest mass to cause flail chest, a potentially lethal condition and a true compression fatality.[4] Historical records exist of judicial "pressing" or the application of chest mass for interrogation or execution.[60] These records of judicial pressing show that about 600 lb is required to kill.

The concept of compression asphyxia as a cause of arrest-related deaths has been thoroughly debunked in the peer-reviewed literature.[61-63]

The hypothesis of ventilation interference has also been thoroughly debunked.[27,28,47,64-68] Impressive experiments have been done in which volunteers were: (1) prone, (2) hog-tied, and (3) compressed with up to 225 pounds on the back.[34] See Figure 16.

Figure 16. Maximally restrained prone subjects have very adequate ventilation.[69]

Mechanical (Physical) Control

For an arrest related death, there are several scientifically legitimate issues to consider with physical control:

1. Airway restriction from neck compression.
2. Excessive force on the rib cage.
3. Simultaneous high forces on *both* the rib cage and abdomen.

Airway Restriction from Neck Compression.

The autopsy report found no minor or major injury to the neck.

> The skin of the neck is dissected up to the angle of the mandible. There is no evidence of trauma to the soft tissues, major airway, or vital structures in the neck. There is no airway mucosal edema. The hyoid bone and laryngeal cartilages are free of fracture. The epiglottis is not inflamed or swollen. No foreign objects are in the airway. The carotid vessels are pliable and patent. The anterior cervical spine and atlantooccipital joint are stable to manipulation.

Figure 17 shows the neck of Mr. Rodriquez well illuminated by a CEW flashlight and completely untouched by any of the officers.

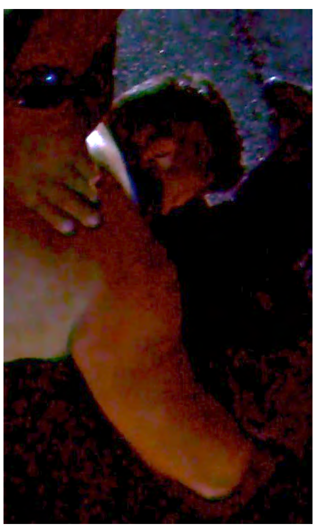

Figure 17. Clear view of neck at 22:21:19 (Lewis BWC @ 22:20:59)

Excessive Force on the Rib Cage.

Significant force on the rib cage can break enough ribs to prevent both thoracic and diaphragmatic (abdominal) breathing. This is a common cause of death from crowd trampling and trench cave-in accidents. This requires about 570 pounds of weight on the rib cage.[4] There is no evidence of such high force being applied to Mr. Rodriguez' rib cage and, in fact, it is nearly impossible unless 2 very heavy officers stood on the rib cage with both feet.

In addition, the autopsy report did not mention any broken ribs.

Simultaneous Forces on *Both* the Rib Cage and Abdomen.

With thoracic restrictions, a person can still breathe diaphragmatically (belly breathing); with abdominal restrictions, a person can still breathe thoracically.[70,71] Thus it is important to analyze both thoracic and abdominal compressions to see if they were ever simultaneous.

The officer BWC's were synced to each other real-time by timing unique statements and then to real-time by syncing to the corrected CEW clocks. The errors were:

Table 10. BWC Clock Errors

BWC	Clock Error	Direction
Stroud	20 seconds	slow
Bowlden	5 seconds	fast
Lewis	20 seconds	slow
Phillips	22:16:12	"slow" since starting from 0 time
Butera	22:19:38	"slow" since starting from 0 time

Table 11. Restraint Timeline

Item	Real time	Notes	Elapsed Time
Come on bud, roll over on your stomach	22:14:32		0:00:00
RLD position	22:18:07		0:03:35
Hands on upper back	22:18:37		0:04:05
LLD position	22:19:15		0:04:43
All fours	22:19:16		0:04:44
UttShish position	22:19:24		0:04:52
Knee on upper back B	22:19:51		0:05:19
UttShish 2 position	22:19:52		0:05:20
UttShish 2 position	22:20:54		0:06:22
Loud long scream	22:21:43		0:07:11
Long nonsense shouting	22:22:52		0:08:20
Screaming nonsense	22:24:40	Breathing	0:10:08
UttShish	22:24:58		0:10:26
Proned	22:25:13		0:10:41
"Dude keep your head down"	22:25:39	Viable	0:00:26
Rod makes whiny/crying sound	22:25:43	Breathing	0:00:30
"Keep your face down"	22:26:05	Viable	0:00:52
Knee on left hip	22:26:17		0:01:04
"Don't move" (breathing heard)	22:26:23	Viable	0:01:10
"Don't move"	22:26:49		0:01:36
Jerks leg	22:27:10		0:01:57
Estimated time of cardiac arrest	*22:27:24*		0:02:11

"Pulse rate is thru the roof"	22:27:38		0:01:59
"Still breathing brother?"	22:27:42		0:02:03
"He's holding his breath"	22:27:47		0:02:08

If we time the beginning of the restraint attempts to the command "Come on bud roll over on your stomach," then there was 10.7 minutes (10:41 min:sec) before the prone position is see on the video. (Outside of a very brief period at 22:18:37 with only hand restraint.) Mr. Rodriguez went from an RLD (right lateral decubitus) position to an LLD (left lateral decubitus) position then to all fours and finally to the UttShi (Uttana Shishosana) position before he was finally proned.

At 22:27:10 we have the last sign of movement and at 22:27:38 his pulse was checked. I estimated the time of cardiac arrest at the average between these 2 times or 22:27:24. That gives an estimated 2:11 (min:sec) for the time in the video-confirmed full-prone position before the cardiac arrest. Normal breathing typically ceases in 12 to 15 seconds after a cardiac arrest and thus this timing it is consistent with the questions about his breathing and the comment that he was holding his breath. [72,73]

Thus, Rodriguez was in the prone position for about 1/6 (17%) of the time of the restraint attempts. During the first 10.7 minutes, there was clearly no breathing restriction possible with the RLD, LLD, all fours, and UttShi positions.

Note there was never any significant force (such as a knee) on the abdomen. The 2 restraining knees were only on the upper central back and left buttocks as seen in Figure 28. Even if we were to assume *hypothetically* that there had been force on the abdomen during the prone positioning, there was still in an insufficient time to cause compression asphyxia since that requires 4 minutes versus the little over 2 minutes in the prone position.

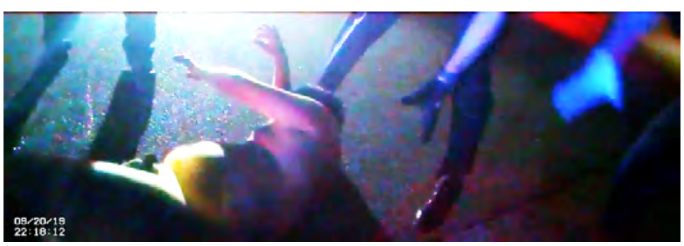

Figure 18. RLD position at 22:18:07 (Bowlden @ 22:18:12)

Figure 19. Brief proning with only hands on back at 22:18:37 (Bowlden @ 22:18:42)

Figure 20. LLD position at 22:19:15 (Lewis @ 22:18:55)

Figure 21. On all-fours at 22:19:16 (Lewis @ 22:18:57)

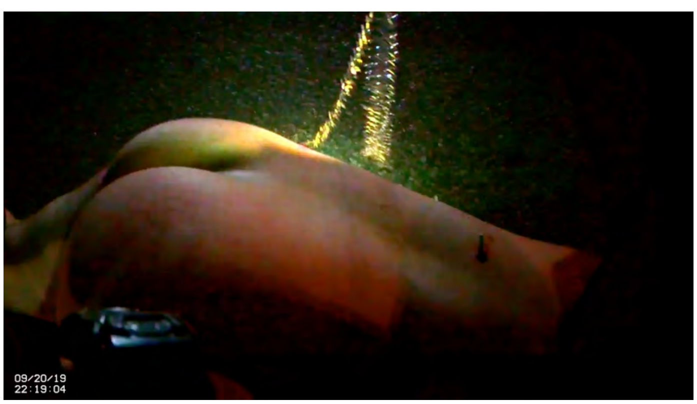

Figure 22. UttShi position at 22:19:24 (Lewis @ 22:19:04)

As seen in Figure 23, a large portion of the knee restraint was during the UttShi position and thus there was no interference possible with diaphragmatic breathing.

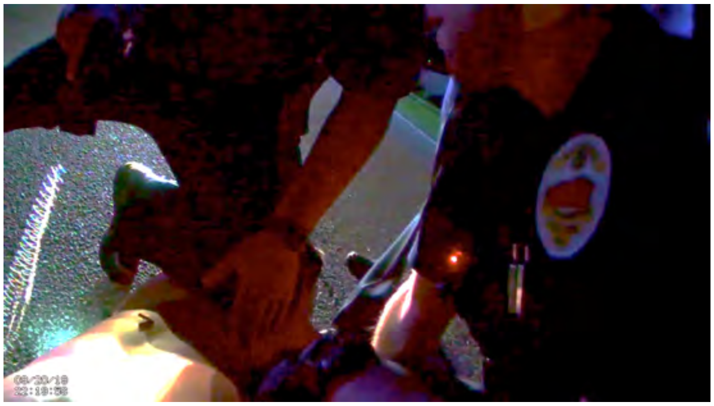

Figure 23. Knee on upper back at 22:19:51 (Bowlden @ 22:19:56)

Figure 24. Still in UttShi position at 22:19:52 (Lewis @ 22:19:32)


Figure 25. Still in UttShi position at 22:20:54 (Bowlden @ 22:20:59)

Figure 26. Still in UttShi position at 22:24:58 (Lewis @ 22:24:38)

Figure 27. Proned at 22:25:13 (Lewis @ 22:24:53)

Figure 28. Prone position at 22:26:17 (Lewis @ 22:25:57)

Prone Knee Force

Ofc. Phillips placed his left knee on Rodriguez' left shoulder and later across the upper back. Ofc. Phillips weighed 215 lbs. at the time of this incident. Combining that with 30 lbs. of duty belt would give him a total effective weight of 245 lbs. The predicted single knee weight force ranges from 55-73 lbs. depended on the positioning and technique.[1] Taking the conservative 73 lbs. We see that the knee restraint provided 32% of the 225 lbs. that are known to be without significant breathing restrictions. The 73 lb. on the back was well below the 400 lb. of prone weight ventilatory compromise value from crowd-crush research.[35-37]

There was no abdominal restriction and thus there was no compromise of diaphragmatic breathing.

During this brief period of the prone restraint, Mr. Rodriguez was still able to yell which shows ventilation.

The officers in this incident demonstrated an unusual degree of caution regarding the placement of weight on the thorax. Instead, they placed weight on the thighs, legs, and leg shackles where there would be no possible interference with ventilation.

Autopsy Report of Dr. Steven Atkinson

I reviewed the autopsy report of Dr. Steven Atkinson and wish to comment on those opinions that may not comport with the peer-reviewed scientific literature.

Background

My specific credentials for the review of a Forensic Pathologist's report, regarding an arrest-related-death include, but is not limited to:

- Invited lecturer to full audience of the 2006 NAME (National Association of Medical Examiners) conference.[74]
- Invited lecturer to full audience of the 2007 Advanced Death Investigation Course of St. Louis University.[75]
- Faculty lecturer to full audience at Institute for the Prevention of In-Custody Death Conferences (2006 and 2007).
- Invited lecturer to 2007 AAFS (American Academy of Forensic Science) conference.[76]
- Lecturer to full audience of the 2015 NAME (National Association of Medical Examiners) conference.[77]

In addition to being asked to educate medical examiners and forensic pathologists at their major meetings as listed above, I was invited to provide the chapters on electric weapons for these textbooks used by Forensic Pathologists:

- Stark: Clinical Forensic Medicine (3rd Ed.)
- Fish & Geddes: Electrical Injuries (2nd Ed.)
- Payne-James & Byard: Forensic & Legal Medicine: Clinical & Pathological Aspects.

I was also invited by the British "Journal of Forensic and Legal Medicine" to write a review article on CEWs and this was published in 2009.[78] This paper, "Physiology and Pathology of TASER Electronic Control Devices" has already been cited in 58 other publications. I have also published numerous peer-reviewed articles in forensic pathology journals to help educate medical examiners on arrest-related death scientific issues.[1,2,6,78-88]

In addition, I testified in court (2008) in the successful action by the City of Akron (Ohio) and TASER International, Inc. against the Summit County Medical Examiner's Office. This court decision — upheld on appeals — forced the medical examiner's office to correct 3 erroneous autopsy reports incorrectly blaming 3 deaths on "electrocution" by a CEW. I also testified (2009) before a Grand Jury in Tarrant County (Texas) against an erroneous medical examiner's autopsy report blaming a death on "electrocution" by a CEW. In this case the

Medical Examiner's opinion also then changed at his deposition in the civil litigation that followed. I also testified in a jury trial (2010) in Winn Parish, Louisiana against an erroneous coroner's determination, based upon an internationally known forensic pathologist/medical examiner (Michael Baden), Coroner's finding, and nationally-recognized forensic pathologist wrongly blaming a death on "electrocution" by a CEW. In 2014 I testified in a Motion-in-Limine hearing against the speculative theories of a physician in the *Downen v. Columbia Falls* case in Federal Court (Missoula District, Montana) and this resulted in the physician's testimony being significantly limited. Specifically, the Court ruled:

> In light of no discernable methodology and the testimony of Mark Kroll, Dr. Peschel is not allowed to testify regarding his opinions on electroporation and the role he alleges it played in hastening Downen's death.

In Todero v Blackwell (Federal Court, Indianapolis) the plaintiffs expert, Dr. Rashtian opined that multiple CEW trigger pulls had caused muscle breakdown leading to the decedents death from kidney failure caused by those muscle breakdown products (rhabdomyolysis). I opined and testified that such electrical shocks would not cause rhabdomyolysis and that the scientific literature suggested more common causes of over-exertion and drug use. The court ruled:

> Defendants cite, and Ms. Todero does not challenge, a medical journal article listing exertion, medicinal drug use, infections, endocrine disorders, and neuroleptic malignant syndrome—but not electrical shock—as causes for rhabdomyolysis. Dr. Rashtian did not account for those potential causes. … Nor did he provide any evidence that electrical shock causes rhabdomyolysis as commonly or more commonly than those other potential causes…. That failure to account for several other potential causes makes Dr. Rashtian's methodology unreliable, undermining his opinion that the Taser caused Mr. Todero's death…. Dr. Rashtian therefore **may not opine** about what caused Mr. Todero to experience rhabdomyolysis. [emphasis present in the original ruling]

In addition, my experience includes reviewing, analyzing, interpreting, and commenting over 1000 autopsy reports in arrest-related deaths since 2004. These experiences were based upon my knowledge, experience, education, training, and skills as a biomedical scientist as well as my extensive studies and writings. Also, I have served as an expert in over 160 litigated cases involving arrest-related injury and death, in addition to the above brief listing and my attached detailed CV.

Comment on Opinions

Dr. Atkinson opined that the cause of death was:

> Asphyxia due to physical restraint in prone position with compression of chest.

This opinion does not comport with the facts and scientific literature for the following reasons:

1. A speculation of asphyxia is contradicted by the minimal weight on the chest and the fact that Mr. Rodriguez was able to yell during his restraint.

2. A speculation of asphyxia is contradicted by the fact that there was no weight on the abdomen.

3. The listing of the prone position suggests a misunderstanding of the scientific literature on the effects of prone positioning.

4. There was no autopsy evidence of chest compressions — such as broken ribs — found.

Materials Reviewed or Considered:

Pleadings:
- Complaint

Videos
- Stroud
- Lewis
- Bowlden
- Phillips
- Butera

CEW Downloads
- Lewis
- Bowlden
- Phillips

Police Reports
Autopsy Report

Benefits and Risks of Electronic Control

Electronic control benefits are well-established in the peer-reviewed literature and explain why these weapons are so widely adopted throughout the industrialized world (107 countries). Subject injury rates are cut by ≈ 2/3. The MacDonald study covered 12 USA law enforcement agencies and 24,380 uses of force.[12] They found that the CEW reduced subject injury by 65%. Taylor et al analyzed data from 13 USA agencies including 16,918 uses of force and described a 78% reduction in injuries requiring medical attention.[13] In other words, the use of alternative force options, including hands-on physical force, tends to *at least* triple (3x) the injury rate compared to the CEW. [12,13] The number of law enforcement firearms shootings prevented has been estimated at over 220,000 based on the 4.1 million CEW field uses.[89,90] In agencies using the CEW with minimal restrictions, the fatal officer shooting rate falls by ≈ 2/3.[91] The overall reduction in the ARD (arrest-related-death) rate is 59-66%.[92]

Table 12. Primary risks from CEW probe-mode applications.

Risk	Findings	Notes
Primary (Direct) Risks		
Electrocution	Theoretical possibility with fully embedded dart directly over heart in subjects under 46 lbs.[93] In general, electrocution events in adults is an urban legend.[94-96]	Present CEWs satisfy all world electrical safety standards.
Loss of vision	Demonstrated with probe penetrating the eye.[79,97-99]	
Primary Secondary (Indirect) Risks		
Head injury from fall.	Fatalities demonstrated.[82] Non-fatal injuries demonstrated.[100,101]	
Fume ignition.	Fatalities demonstrated.[84,102]	

The primary demonstrated and theoretical risks supported by the existing literature are outlined in Table 12. The most common contribution to fatality is a secondary injury from a head impact from an uncontrolled fall. If the subject is running or above a hard or elevated surface, and receives a CEW probe deployment, the unbroken fall can sometimes result in a serious head injury and there have been 16 deaths due to this.[82] This has not been reported with the drive (or contact or touch)-stun mode as there is no muscle lock-up. There have been 8 secondary fatalities in which flammable fumes were ignited by an electrical spark from the CEW.[84,92,102] This has not been reported with drive (or contact or touch)-stuns although that remains a theoretical possibility.

The most misunderstood and exaggerated theoretical risk is that of electrocution. This is extremely unlikely as the output of existing CEWs satisfy all relevant world electrical safety and effectiveness standards including those for the ubiquitous electric fence.[14,15,17,20] The conservative IEC (International Electrotechnical Commission) standard allows up to 2.5 W (watts) for an electric

fence and all present TASER CEWs deliver less than 2 W.[18] Underwriters Laboratories (UL) allows 5 W for narrow pulses such as those of TASER CEWs.[19] The primary driver of this myth appears to be the fundraising material of Amnesty International, and some sensationalistic media, that lists Arrest-Related Deaths (ARDs) along with the innuendo that the CEW somehow electrocuted the subject. Notably, they have never attempted to explain how a CEW that satisfies all world electrical safety standards could ever electrocute anyone.

Swine are 3 times as sensitive to electrical current as humans.[103] The largest swine electrocuted by an X26E CEW was that of Valentino with a 10-second CEW discharge and it weighed 36 kg (79 lb.).[104] Nanthakumar also electrocuted a *single* 50 kg swine with a 15 second CEW discharge but he used a drug trick which made the swine's weight equivalent to ≈ 30 kg.[105] Hence the largest swine ever directly electrocuted by a CEW weighed only 36 kg.

The levels of dangerous electrical current scale with body mass just like a drug dosage. Since swine are 3 times as sensitive to electrical current (as humans) this is translated to the single Valentino 36 kg pig to a 12 kg (26 lb.) human.[103] This calculation uses a direct-proportion relationship of dangerous current levels to the body mass. Some authorities have published that the danger level scales with the square root of body mass.[106] With such a relationship the Valentino pig is equivalent to a larger 21 kg (46 lb) human. Taking the more conservative calculation, the best evidence suggests that the risk of CEW electrocution is limited to humans weighing less than 46 lbs.

Most authorities agree that electrocution is a theoretical possibility with an extremely thin individual and a fully penetrated dart directly over the heart in a very thin person with a very small dart-to-heart distance (DTH).[32,107,108]

Table 13. Summary of benefits and risks of CEWs.

	Item	Rate
Benefits:	Subject injury	2/3 reduction
	Subject death	2/3 reduction
Risks:	Fatal fall	1:200,000
	Fatal or nonfatal major burn	1:360,000
	Blindness from dart	1:200,000

The very rare risks of CEW complications are swamped by the lives saved and serious injuries minimized from the reductions of ARDs. For every ARD from a CEW complication (fatal fall or fire) there are 50 ARDs prevented by reducing firearm shootings and over-exertional deaths. Additionally, there is 1 temporal ARD for every 1,000 traditional uses of force, or 1 temporal ARD for every 3,500 uses of CEWs.[82,92]

Relevance to This Case:

1. There was no electrocution risk to Mr. Rodriguez from the X26 weapon.

A Brief Primer on Electrocution.

Low-power electrocution is death from an electrical current from a source under 1000 watts (W).[109] This is contrasted from "high-power" electrocution from power lines or lightning strikes. The death is almost always the result of the electrical current inducing VF (ventricular fibrillation). The electrical induction of VF takes a few seconds at most.[110-121] (A massive electrical injury from a lightning strike or powerline can also cause death by nervous-system damage or kidney failure but that is not relevant here.) Modern CEWs fall in the "low-power" category. The TASER® CEWs all deliver ≤ 1.8 W.

In VF, the heart muscle cells continue to contract but at nearly random times. This is a common cause of cardiac arrest. Hence, there is no coordination among the cells and no blood is pumped from the heart. Loss of consciousness occurs in 13 ± 4 seconds if the person is supine (laying down).[33] If someone is standing or sitting then the collapse occurs within 1-5 seconds.[122,123] Also, the person loses their pulse immediately. Once VF is induced, there is no pulse. There are 6 primary diagnostic criteria required to diagnose an electrocution as shown in Table 14.

Table 14. Primary diagnostic criteria for electrocution.

#	Criterion	Timing
1	Sufficient current delivered to heart.	1-5 seconds of duration. [121] See Background section: *Electricity Does Not Build Up Like Poison.*
2	Loss of pulse.	Instant[73]
3	Loss of consciousness.	13 seconds if laying down.[33] 5 seconds if sitting up.[33,122,123]
4	Loss of normal breathing.	15-60 seconds.[72,73] Agonal breathing (typically 3 minutes) with a maximum of 6 minutes.[72,124,125]
5	Successful defibrillation.	14 minutes with any cardiopulmonary resuscitation (CPR); 9.5 minutes without.[126]
6	VF rhythm.	30-40 minutes after which the VF typically deteriorates to asystole or PEA.[127-131]

A final note on electrocution is that it is a stand-alone cause of death. Electrocution is not like a soup recipe where salt and pepper both contribute to the flavor. It does not "contribute" to other causes of death.[38] For example, if someone with late-stage cancer were to receive sufficient current, they would be dead within seconds and the cancer had nothing to do with it. However, if the same person received a lower level of current and died 30 days later, that person was not electrocuted. People have died as a result of falls from ladders after being startled by an electrical shock. The shock was certainly temporally related to the death, but this is not an electrocution as the fall from the ladder was secondary to the electrical shock. With rare partial exceptions — generally not salient to ARDs — the presence of other disease states does not make someone significantly harder or easier to electrocute. Conversely, low-power electrical currents do not hasten deaths from other diseases.

The CEW has an insignificant effect on a subject's adrenergic and metabolic state.[132-139] However, the effects of metabolic and adrenergic stress on the electrocution threshold have also been extensively studied. The effects, while statistically measurable, are immaterial in the ARD scenario. Adrenergic stress will temporarily lower the VF threshold (VFT) for a few minutes after which the VFT increases.[140,141] The impact for electrical weapons is that the critical dart-to-heart distance (DTH) could increase temporarily to 4-5 mm. Metabolic acidosis also has a similar immaterial effect.[142] Cocaine, a sodium channel blocker, *increases* the VFT and hence makes electrocution even more difficult.[143,144]

Blood has a typical resistivity of 150 Ω•cm and is thus the best electrical conductor in the body along with skeletal muscle (with the grain).[109,145,146]

Misunderstanding the Trigger-pull Download

A common error is to assume that the "TASER" data download in any way represents current delivery to the subject. It does not. It represents only an upper bound on the seconds of current discharged. The total time given by the download is typically 2-3 times what the actual total duration of current delivery was. This is theoretically harmless as the total duration of current is essentially irrelevant to diagnostics since electricity does not build up like poison. Thus, the most exaggerated figures are often the least relevant. However, novice CEW "experts" often stress the total trigger-pull time so it should be addressed.

A TASER download printout showing trigger pull times with a total of, say, 100 seconds provides the following information:

- The times of the trigger pulls (after clock-drift correction).
- The number of seconds of current delivery is 0-100. I.e. somewhere between 0 and 100 seconds.

As an example, in the tragic death of the methamphetamine addict, Robert Heston, (who attacked his father and father's home) there were a total of 206 seconds of trigger-pulls on 5 M26™ CEWs and 6 deployed cartridges used to attempt to control him.[147] A careful analysis found that the actual duration of current delivery was 5-9 seconds. Here the exaggeration was at least 20:1. In a non-USA case (unnamed here due to confidentiality restrictions) there was a total of 154 seconds of trigger-pull duration from 28 trigger pulls. Each CEW had a camera attached and thus the actual duration of current delivery could be determined from an audio analysis.[148] There was a total of only 20 seconds of current delivered.

U.S. Federal Appeals Court decisions recognize that trigger pull records do not equate to delivered current. See *Hoyt v. Cooks*, 672 F.3d 972, 976 (11th Cir. 2012)("The record shows that an 'activation' of the Taser does not mean that the Taser actually touched or stunned Allen."). See also *Bussey-Morice v. Gomez*, 587 F. App'x 621, 625 (11th Cir. 2014):

> the report further notes that in order for energy to be transferred from the Taser via the probes, contact must be made with the individual by both probes to complete the circuit…The TASER log shows only device activation; it does not represent that a shock was actually delivered to a body nor does it distinguish between probe deployment and drive stun.

Causes of Current Delivery Exaggeration:

1. Broken wires or dislodged probes
2. Rounding up to the next second
3. Muzzle contact canting with drive-stuns
4. Muzzle contact and release delays
5. Inadvertent trigger pulls

Broken Wires or Dislodged Darts

A significant reason for multiple or prolonged CEW trigger pulls is that the fragile wires are broken early in the encounter and the officer continues to pull the trigger, hoping for a restraint-helpful response from the subject.

The tiny wires (36 gauge, 127 microns in diameter) are about the diameter of some human hair and are usually quickly broken during any struggle and are typically broken when a subject turns, falls, or flails his arms. The tensile strength, of the wires, is weaker (less than 1 kg) than the weakest fishing line (2 kg or 4 lbs breaking test) and are thus very easily snapped.[149] In fact, in some instances prisoners now teach other inmates that they should roll over if they receive a CEW discharge, in order to break the wires.

Probes are also often lodged in the clothing instead of the skin.

Rounding Up to the Next Second

The reported trigger-pull durations, in the TASER CEW download reports, are rounded up from the first 1/100 of a second. I.e. if the actual duration was 2.01 seconds then it is reported in the download as 3 seconds. Thus, the best estimate of the actual trigger pull is ½ second less than what is reported. Automatic duration trigger pulls of 5 seconds are, in fact, 5.00 seconds and thus there is less risk of an interpretation error there. This is irrelevant with the Trilogy "Pulse-logs" which give trigger pull and arc-switch durations to the nearest 0.1 second and report each pulse.

Muzzle Contact Canting with Drive-stuns

As seen in Figure 29, an effective drive-stun application requires that the CEW muzzle be kept nearly perpendicular to the body surface. This can be difficult to do with a moving subject. A non-analgized non-anesthetized subject will reflexively pull or roll away from the attempted shock. On average, a good contact is only made about 30% of the time. If the muzzle is canted up to 20° away from perpendicular, then an arcing connection can still be made. The typical correction is to subtract 70% from the download times.

Muzzle Contact and Release Delays

With a drive-stun the officer will typically pull the trigger as the muzzle is being brought down towards the subject. The results in the trigger-pull duration overstating the current delivery by about ½ second. If the officer is delivering a drive-stun of less than 5 seconds, they will usually need to pull the weapon back to more easily activate the safety and this release delay also results in the trigger-pull duration overstating the current delivery by about ½ second. In total, the contact and release delays add about 1 second to the actual current delivery time for drive-stuns.

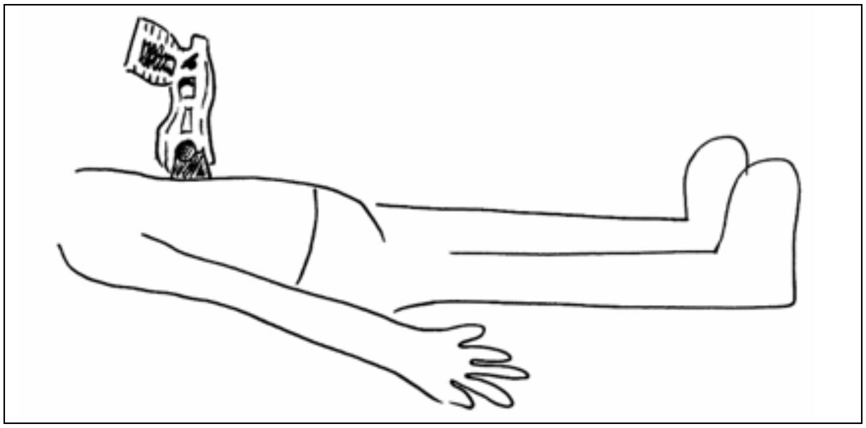

Figure 29. The drive-stun requires that the CEW muzzle be kept nearly perpendicular.

Inadvertent Trigger Pulls

Background:

The inadvertent trigger pull (ITP) has been well studied for firearms discharges.[150,151] According to Heim there appear to be 3 primary causes:[150]

1. sudden loss of balance;
2. contractions in the hand holding the weapon while other limbs are in use, for example during a struggle with a suspect;
3. startle reaction.

Common to every incident, in addition to the weapon being held in a hand, is that all limbs appear to be involved in the resulting sudden movement.[150] Recent work by the Lewinski group found no cases of firearm ITPs involving startle.[152] We have also not seen situations where a startle reaction led to a CEW ITP and thus we will focus on #1 and #2 above. Another potential cause is the *fist* reflex which is natural from birth and can be reinforced by training with closed-hand strikes; this can occur in a high stress confrontational situation.[153,154] The fist reflex may not apply to CEW ITPs and will not be discussed further here.

Physiology:

It has been recognized for over 100 years that muscle contractions in any limb can lead to increased activity in other limbs.[155] This has generally been referred to as *motor overflow* or *overflow activity*.[156,157] This is especially seen in opposite (contralateral) limbs where the phenomenon is referred to as *mirror movement*.[158-161]

When we contract a *single* hand firmly we also *invariably* contract the opposite hand somewhat.[162] Typical male grip strength is 130 ± 16 pounds where 25- 42% is exerted by the index finger.[163] Overflow activity can reach a maximum of 25% of the maximum voluntary force of the individual limb.[164] Thus, forces of up to 14 pounds (= 25% • 42% • 130 lbs.) can be involuntarily exerted by the index finger.[150] This is sufficient to overcome the trigger pull (8-

12 lbs.) for the 1st round of an uncocked double-action pistol. Even when warned to keep their fingers off of the trigger — and knowing that they were being studied — 21% of officers contacted the trigger for > 1 second in stress simulations.[150] When studied with their index finger already on the trigger, 28% (=7/25) of volunteers gave involuntary trigger pulls of > 14 lbs. when they either pulled with their opposite arm or lost their balance.[150]

Effect of Officer Age:

Shinohara studied the contralateral hand contraction in 10 young (18-32 yo) and 10 old (66-80 yo) right-handed subjects.[173] For young people, the contralateral force was greater when the right (dominant) hand was voluntarily activated. For old people, there was no statistically significant difference between the hands. As seen in Table 4, the strongest mirror index finger force was in older subjects; the weakest was in the right hand of the young subjects. Due to the mechanical restrictions imposed on both hands, the MVC (Maximum Voluntary Contraction) was < 20% of what can be measured on an unrestricted hand and arm.[174] Force is given in newtons (N).

Table 15. Shinohara contralateral index finger contractions.

Subjects	Hand	MVC (N)	Involuntary	Involuntary (N)
Young	Right	25.8	4.7%	1.21
Young	Left	25.5	9.1%	2.33
Old	Right	29.9	13.8%	4.13
Old	Left	27.6	11.4%	3.15

Shinohara concluded, "The results indicate that old subjects have a reduced ability to suppress unintended contralateral activity." This is clearly seen in Figure 30.

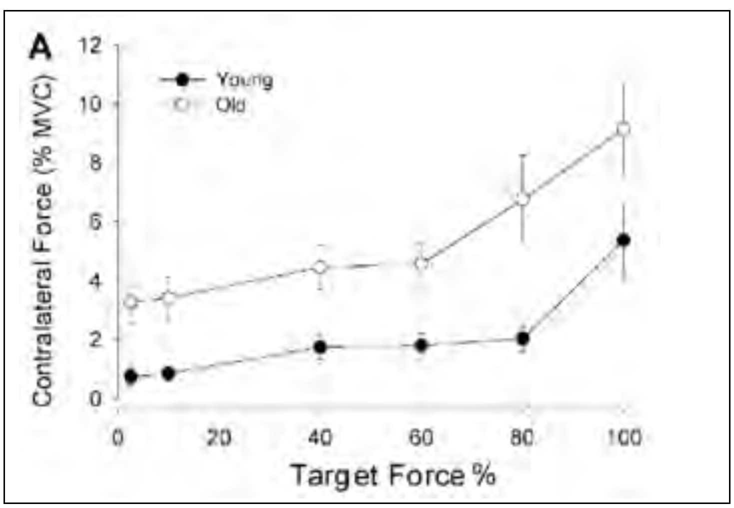

Figure 30. Shinohara study showing increased contralateral activity in older subjects.

The combination of involuntary muscle contraction activity and a finger on the trigger (which was either unconsciously pre-positioned or moved with the involuntary activity) is responsible for many inadvertent firearm discharges by law enforcement officers.[151,152,165]

Comparison to Firearms:

With the conducted electrical weapon (CEW), the incidence of ITPs is far greater — than with firearms — for 2 primary reasons:

1. The CEW trigger pull is far less at only 2 lbs. for the popular X26 (X26E) CEW and 3 lbs for the X2 CEW. The trigger is thus 3-6 times more sensitive than that of an uncocked double-action pistol.
2. Officers commonly hold the CEW in their dominant hand and attempt to assist with subject control or lifting with the other hand. They would never do this with a firearm as it is forbidden by weapons retention training.

Ironically, the situation is both far worse but also far better for the CEW compared to the firearm. While a CEW operator will have far more ITPs, the results are almost always harmless compared to the often-fatal consequences of a firearm ITP.

The Harm of the Helping Hand:

A major cause of mirror-movement ITPs is an officer trying to help control a subject with the non-dominant hand while keeping the CEW in the dominant hand. In a helping hand scenario, at least 2/3 of the trigger pulls are ITPs.

We have investigated many incidents in which the *majority* of trigger pulls appear to be ITPs. In the typical case the officer is maintaining his grip on the weapon while trying to restrain the subject with the free hand and possibly also the CEW-constrained hand. This can also occur while holstering the weapon if the opposite hand is being engaged in the struggle. Thus, during a physical struggle with the CEW in an officer's hand, most of the CEW discharges tend to be mirror-movement ITPs which then run the full standard default 5 seconds or until, or if, the officer realizes what is happening (from the arcing sound) and turns the weapon OFF (safety ON). In many cases, the arcing sound is not noticed because of the yelling, environmental noise, or the focus on a struggle.

Incidents with multiple (>3) trigger pulls and full documentation (Trilogy pulse-logs and body-cameras) have been analyzed to determine the relationship between the trigger pull time-totals and the actual seconds of current delivered. The interesting finding is that the actual seconds of current begins to level off at 10-15 s so the percentage of time continues to decrease from ~35% down to as low as 5%.

Most of the CEW ITPs occur with drive-stuns which are well established as having no deleterious effects outside of short-term minor contact burns.[166-

[168] Moreover, the inadvertent drive-stun trigger pull is almost always with the weapon far away from the subject as the officer's opposite hand is the one in contact with the subject. For the minority of cases that began as a probe-mode deployment, the connection has usually been broken by the grounding, attempted restraint, or ground struggle. If a full probe connection was still existing, then there would be far less need for manual control and hence a low likelihood of an ITP.

Forensic Evidence

After 2 seconds of drive-stunning through clothing, small sunburn-like marks will be left. A drive-stun leaves a pair of distinctive marks due to the 40 mm fixed distance between the muzzle electrodes.[168] This is depicted in Figure 31.

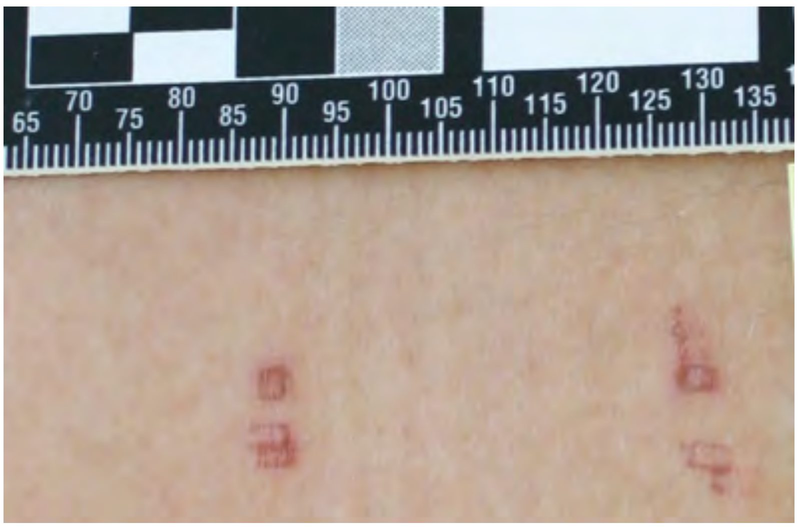

Figure 31. Drive-stun marks.

For probe-mode applications, microscopic analysis of the "eye of the needle" in the back of the probe can estimate the duration of the current delivery.[169,170]

The newer model CEWs, X2, X26P, and T7 allow the duration determination from the enhanced "Pulse Log" download.

The Significance of the Sound

The X26E CEW is fairly quiet at 51 decibels (dBA) @ 1 meter, when it has a completed circuit connection. The X26E is much louder when it is arcing and *not* completing a circuit (79 dBA @ 1 m). This is like many devices that are quiet when working properly and louder when not. Sound levels from ordinary sources as seen in Table 16.

The scientific basis of the crackling sound emitted from an electrical arc has been well studied.[171-173] This distinction is also known to CEW-trained law enforcement officers, and easily demonstrated in many ways such as arcing to a soda can or across the CEW muzzle.

Table 16. Sampling of sound levels from various sources.

Sound level (dBA @ 1 m)	Source
90	Train whistle (@ 150 m)
79	X26E CEW open-circuit crackling
70	vacuum cleaner
60	polite conversational speech
51	X26E CEW closed-circuit clicking
50	average home volume, normal refrigerator
40	quiet library
30	quiet bedroom at night

There is indeed a dramatic difference between the open circuit arcing and intact circuit sound level. When the X26E CEW is deployed with a completed circuit (such as contacting a body) it makes a relatively soft clicking noise which is softer than normal conversation and on the order of the sound from a properly operating refrigerator. However, in the open-circuit mode — such as when a wire is broken, a probe misses, there is a clothing disconnect, intermittent disconnect, or a probe is dislodged — the sound level is 79 dBA which is well above that of a vacuum cleaner. The difference between 51 dBA and 79 dBA is logarithmic and actually corresponds to a ratio of:

$$
\begin{aligned}
\text{Ratio} &= 10^{((79-51)/10)} \\
&= 10^{2.8} \\
&= 631
\end{aligned}
$$

Thus, the X26E CEW in arcing mode has 631 times the sound *intensity*. This arcing sound is heard with a spark test. With a closed circuit (good connection) the sound cannot be easily heard over loud conversation and generally not over yelling and shouting. The arcing (open-circuit) sound is not only much louder but has a *different* sound. It is often described as a "crackling" sound as opposed to a "clicking" sound. The "crackling" sound is so different that it can be

easily differentiated by zooming in on the sound recording as depicted in Figure 32. The top tracing is the instantaneous sound level of an X26E CEW that is arcing (at the muzzle) while the lower tracing is of an X26E CEW with an intact circuit. Note that 3 pulses are shown in each tracing. The X26E CEW discharges at a pulse rate of ≈ 18.3 PPS (Pulses Per Second) so the pulses are about 55 ms (milliseconds) apart. Note that the top (arcing) tracing intuitively appears "noisier" — which it is. The lower tracing of the connected intact completed circuit "clicking" sounds shows that they are much "cleaner."

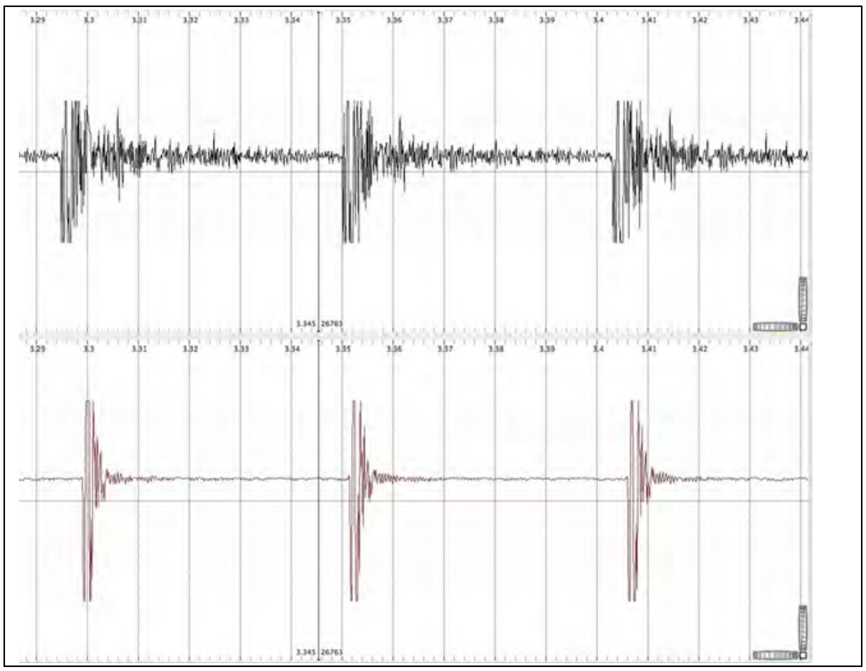

Figure 32. X26E CEW sound signatures of open circuit and closed circuit pulses.

The excursions of the sound level signal saturate the TASER CAM storage until the AGC (Automatic Gain Control) can automatically "lower the volume." That is why the louder crackling sound actually appears shorter in height. For a good connection, these excursions last about 2 ms as seen in the lower trace. For arcing, these excursions last ≈ 4 ms as seen in the upper trace.

General Background:

A. The Electrophobia Myth

Many people have an illogical emotional fear of electricity or *electrophobia*. From an early age in life it is drilled into young children that 110 V (volt) electrical outlets cause death, Thus, most people have deeply absorbed the urban myths that voltage itself is dangerous and 110 V causes death. While most people learned to dispel this myth in middle-school sciences classes it is often forgotten by adulthood. While this is scientifically incorrect most people, including most media, hold these myths to be undeniable truths.

Life itself could not exist without electricity. Trying to say that all electricity is dangerous is equivalent to saying that all balls are dangerous. There are marked differences in the effects of being struck by a ping-pong ball, baseball, bowling ball, and wrecking ball.

Table 17. AC Currents and Their Typical Effects

AC Current (mA)	Effect
1500	Nerve Damage
1000	
500	Cardiac Arrest Probable
200	
100	Cardiac Arrest Possible
50	Interference w Breathing
18	TASER ® Weapon (AC Equivalent)
16	Male No-let-go threshold
10	Muscle Contractions Begin
5	Pain Sensation
1.1	Male Hand Perception
0.7	Female Hand Perception

The typical effects of various AC currents are shown in Table 17. The < 2 mA of pulsed DC current (for the TASER® CEWs) is not directly comparable so a 18 mA AC equivalent is used.[174]

B. CEW Probe Mode

In probe mode, the TASER® handheld CEW uses compressed nitrogen to deploy 2 small probes at typical distances of up to 7.7 m (meters) or 25 feet.[175,176] (Other cartridge models can reach a distance of 11 m or 35 feet.) When the CEW trigger is pulled, the high voltage pulse first serves to activate a primer which opens the nitrogen cartridges to release the nitrogen to propel the probes as directed. These probes themselves are designed to pierce or become lodged in most light clothing (and to complete the circuit with the 50 kV arcing capability). The sharp portion of the probe is 9-13 mm (millimeters) long

and will typically penetrate the epidermis and dermis to a depth of ~6 mm for a good electrical connection.

The ultra-short duration electrical pulses applied by TASER CEWs are intended to stimulate Type A-α motor neurons, which are the nerves that control skeletal muscle contraction, but without a high-risk of stimulating cardiac muscle. This typically leads to a loss of regional muscle control and a fall to the ground to end a violent confrontation or suicide attempt.

Small swine of 30 kg (65 lbs) can be put into VF when the CEW probes are put within a few mm of the heart. [104,177] One study used a custom long plunging probe to deliver the CEW current almost directly (within 6 mm) to the heart of a pig in order to induce VF.[178] There are numerous problems with the swine model that significantly exaggerate the electrocution risk. [177,179] Pigs are extremely sensitive to electrical currents due to their hearts being literally wired "outside-in" compared to a human's (being wired "inside-out").[180-185] The swine heart needs 2/3 less current to induce VF (ventricular fibrillation) compared to the human heart from external stimulation. In other words, the swine is 3 times as sensitive to electrocution as is the human.[186] This CEW-electrocution effect is also confined to *small* swine.[108] In stark contrast, human studies consistently demonstrate no risk of VF with a CEW application.[187-191]

This is clearly the consensus of the scientific and medical community as shown by various position papers. For example: the June 2009 American Medical Association (AMA) White (Position) Paper concluded:[192]

> Furthermore, no evidence of dysrhythmia or myocardial ischemia is apparent, even when the barbs are positioned on the thorax and cardiac apex.

On May 24, 2011, the National Institute of Justice, after a 5-year panel review, concluded:[193]

> Current research does not support a substantially increased risk of cardiac arrhythmia in field situations, even if the CED darts strike the front of the chest. There is currently no medical evidence that CEDs pose a significant risk for induced cardiac dysrhythmia in humans when deployed reasonably.

Finally, in June 2012, Bozeman stated:[190]

> The risk of such dysrhythmias, even in the presence of a transcardiac CEW discharge, is low, and suggest that policies restricting anterior thoracic discharges of CEWs based on cardiac safety concerns are unnecessary.

No danger or harm has been associated with the CEW probe-mode application, in human studies.

C. CEW Drive Stun Mode: Skin Rub vs. Injection

Alternatively, the CEW may be used in a "drive-stun" mode by pushing the front of the weapon into the skin to function as a higher charge stun-gun. With the fixed electrodes, only 4 cm (centimeters) or 1.6 inches apart — and the lack

of skin penetration — the current flow is primarily through the dermis and fat layer between the electrodes and there is no significant penetration beyond the subdermal (or subcutaneous) fat layer. See Figure 33. Since there is insufficient depth of current flow to capture muscles, the drive-stun mode serves only as a compliance technique. To make an analogy to medicine, drive-stun is like rubbing an ointment on the skin compared to the probe mode, which is like an injection. They have significantly different effects.

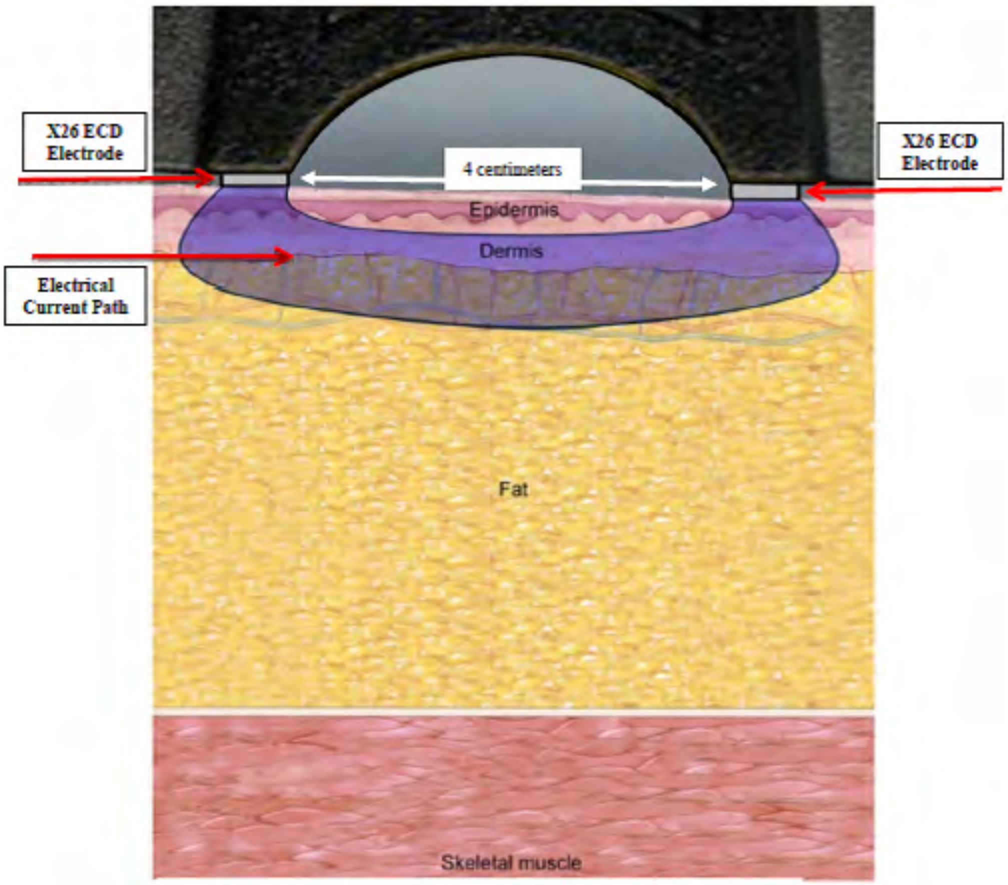

Figure 33. The majority of the drive-stun current is confined to the fat and dermis layer.

As mentioned above, small swine (30 kg or 65 lbs) can occasionally be put into VF when fully-embedded CEW probes are nearly touching the heart.[194,195] However, it is impossible to fibrillate even small swine with a transcutaneous CEW drive-stun application.[196-199] The electrical current simply does not penetrate deeply enough to affect any human muscles or organs. In fact, with a CEW drive-stun application directly over the human phrenic nerves (the nerves that control breathing) there is no effect.[200]

The National Institute of Justice, 5-year study of CEWs, found:[193]

> Risk of ventricular dysrhythmias is exceedingly low in the drive-stun mode of CEDs because the density of the current in the tissue is much lower in this mode.

The American Academy of Emergency Medicine (AAEM) has the following guideline on drive-stun applications:[201]

> For patients who have undergone drive stun or touch stun ECD exposure, medical screening should focus on local skin effects at the exposure site, which may include local skin irritation or minor contact Allen. This recommendation is based on a literature review in which thousands of volunteers and individuals in police custody have had drive stun ECDs used with no untoward effects beyond local skin effects.

The Federal Court of Appeals for the 9th Circuit [*Brooks v Seattle*], and others, have concluded:

> The [TASER CEW]'s use in "touch" or "drive-stun" ... involves touching the [TASER CEW] to the body and causes temporary, localized pain only. ... this usage was considered a Level 1 tactic, akin to "pain compliance applied through the use of distraction, counter-joint holds, hair control holds, [and pepper spray]" and used to control passively or actively resisting suspects.

CEW drive-stun applications have no clinically significant physiological or pathological effects.

D. Current Flow in the Body

The flow of electrical current in the body is well understood and has been the subject of 100's of scientific papers.[202-211] The simplest analogy is the 1st to 2nd baseline in baseball. See Figure 34. The runners can go directly between the bases but they typically curve out a bit. Similarly, with 2 electrodes in the skin, the current flow "dives" in somewhat just like a runner's path in baseball. The further the electrodes are apart, the deeper the "dive" of the current. This analysis is accurate for a homogenous conductor like saltwater or fat. However, the body's skeletal muscle layer preferably directs current around the outside of the body since electrical current vastly prefers to follow the grain of the muscle instead of going transverse and penetrating the body.

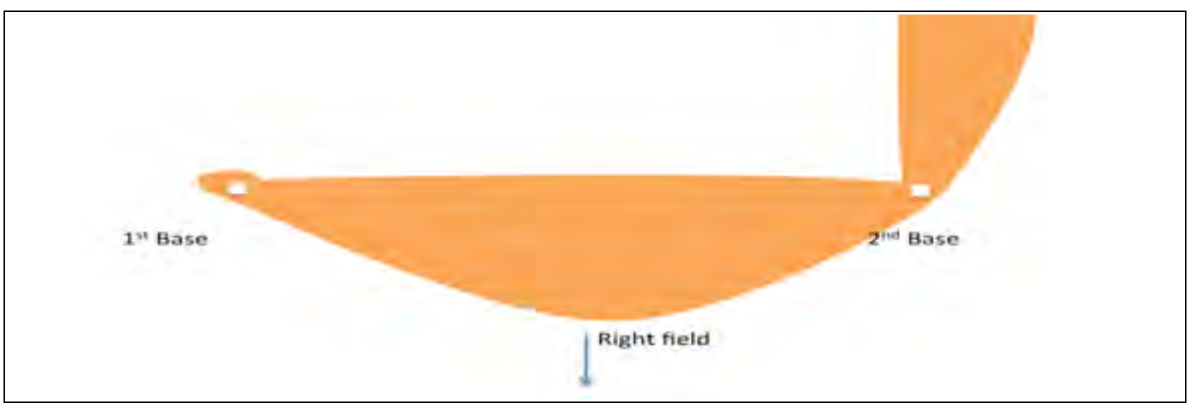

Figure 34. Graphic of electrical current flow in the body analogized to baseball.

Some medical examiners have wrongly opined that since they witnessed a subject experience board-like lockup induced by a CEW that the current flows everywhere even inside the body.

A runner might deviate somewhat from a straight line but would never run out into the outfield or wander into the bleachers. Similarly, with 2 CEW electrodes on the chest, no current passes into the legs or brain. That would be like a runner going into the outfield and then climbing up into the seats and then back to 2nd base.

An important exception occurs around bone. Mature calcified bone is an insulator and can thus not conduct electrical current.[212] A CEW probe landing in the sternum will pass very little current. What current is passed will be defused around the surface of the chest and will tend to not affect the heart even though parts of the heart are directly beneath the sternum.[202,213]

Electrical current in the body tends to follow muscle fiber and only deviates slightly.

E. CEW Comparison to Other Nerve Stimulators

TASER CEWs deliver less current than typical models of EMS (Electrical Muscle Stimulator) units. It is very popular in Europe to use TENS (Transcutaneous Electronic Nerve Stimulator) units for treating angina with the electrodes placed across the cardiac silhouette.[214-216] No deaths have been reported.

Figure 35. Electrical muscle stimulation is widely used for muscle training.

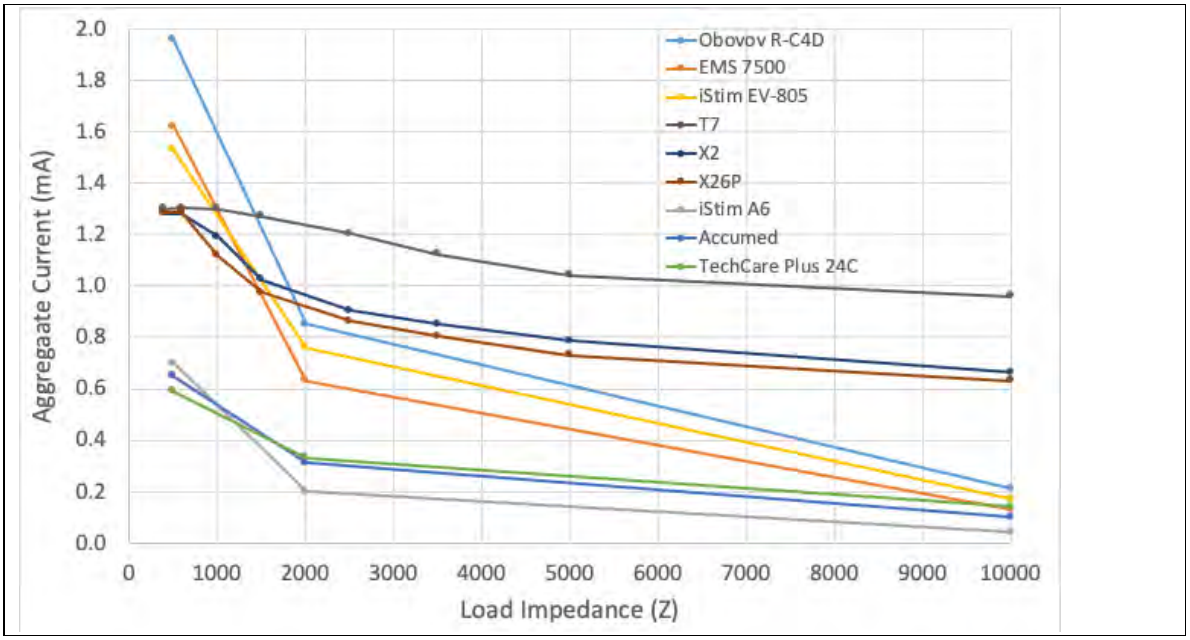

Figure 36. Aggregate current vs. load impedance.

The outputs of the TENS and EMS units are compared with the electrical-weapon muscle stimulators as seen in Figure 36. In the typical impedance range of around 500 Ω, the EMS units delivered the most current followed by the CEWs (T7, X2, and X26P).[217]

Figure 37. Subject using Miha Bodytec system.

Whole body electro-myostimulation (WB-EMS) is an new extreme athletic training technique that recently originated in Germany with a device called the Miha Boytec.[218] The subject strips naked and then dons the electrode jacket as shown in Figure 37 and Figure 38. Additional electrodes are placed on the legs.

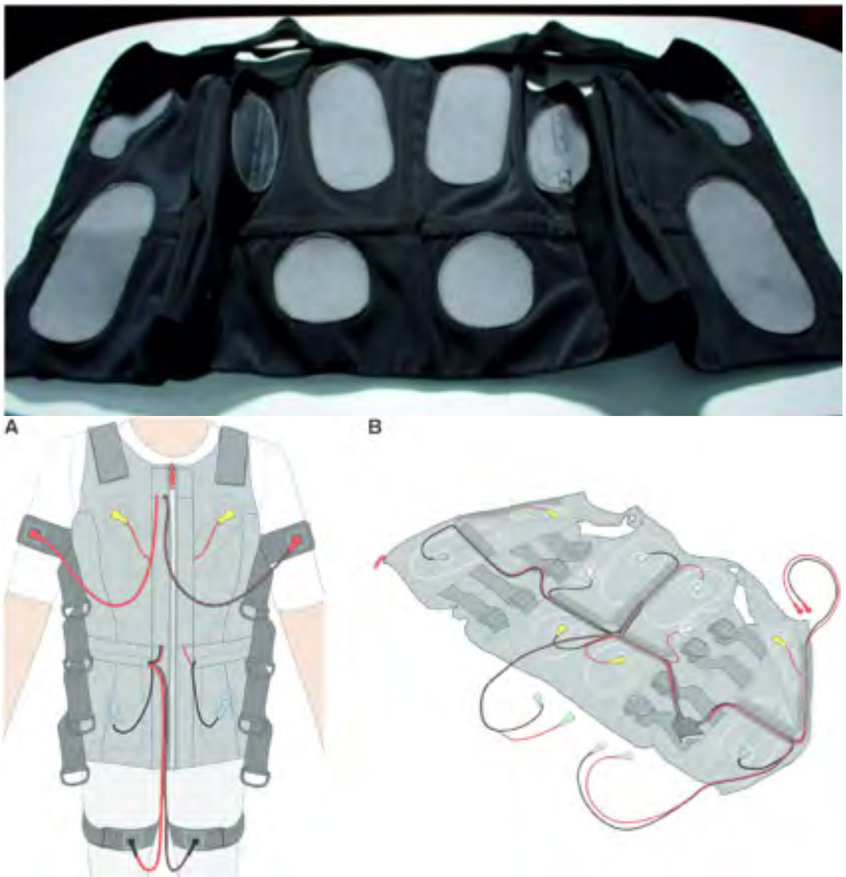

Figure 38. Miha Bodytec WB-EMS electrode vest.

Table 18. Comparison of X26 CEW to the Bodytec system.

	TASER® X2 CEW	Miha Bodytec
Electrodes/Channels	4/2	20/10
Pulse rate (per second)	19.6	2-150
Pulse duration (μs)	71	50-400
Typical duration (s)	10	1200
Pulse charge (μC)	65	< 32
Aggregate current (mA)	1.3	< 4.8
Aggregate current over all electrodes/channels (mA)	2.6	< 48

As seen in Table 18, there is a world of difference between the level of stimulation between an X26 CEW and the Miha Bodytec WB_EMS system. The Bodytec delivers more current per electrode pair and over 10 times the total current to the body.[217]

F. ANSI CPLSO-17 Standard

All present TASER brand electrical weapon outputs exceed the minimum requirements for effectiveness under the ANSI CPLSO-17 standard. These output levels are also below the maximum safety limits under the ANSI CPLSO-17 standard of 2.2 mA.

G. CEW Comparison to the Electric Fence

It is helpful to discuss the most common and longest existing electronic control device — which controls humans and other mammals by giving short painful electrical stimuli — namely the electric fence.

The IEC (International Electrotechnical Commission)and UL (Underwriters Laboratories) have long had standards for electric fences.[18,19] These are the Particular Requirements for Electric Fence Energizers. IEC 60335-2-76, edn 2.1, and the UL Standard for Electric-Fence Controllers in: Laboratories U, ed. UL 69. Independent testing has verified that the TASER X26E CEW satisfies both the IEC and UL electric fence standards.[14] The X2 and the X26P CEWs also satisfy these standards.[15]

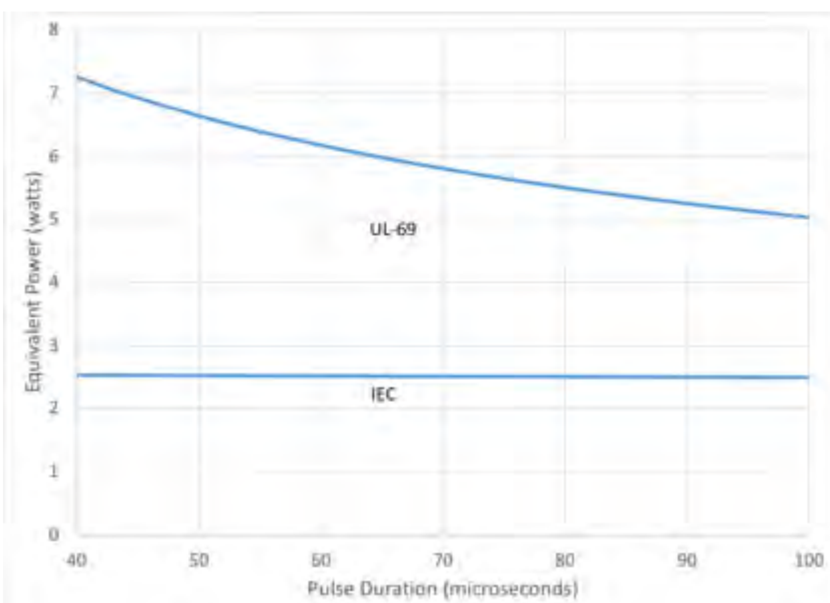

Figure 39. UL 69 electric fence equivalent power safety limit.

The X26 CEW satisfies the electric fence standards by a very wide margin.[14] The conservative IEC standard allows up to 2.5 watts (W) for an electric fence and all present TASER CEWs deliver <1.8 W. The UL high-rate limits are found in section in 23.2.4 of the UL standard 69.[19] This limit is shown in Figure 39 which allows 5 W for the wider-pulse X26 CEW and 6 W for the narrow-pulse X2 CEW. The electric fence standards have evolved from almost 100 years of experience with documented fatalities from earlier high-powered devices. The UL carefully collected data on these units to find out what was a safe limit. The typical

accidental exposure to an electric fence is based on someone walking into it and thus is a frontal exposure. Depending upon the relative heights of the fence and the individual this exposure could be anywhere from the face to the thighs and could include skin penetration from barbs on barbed wire. These limits are very stringent and now fatalities from electric fences are almost unheard of in spite of there being on the order of 100,000 miles of electric fence in the United States alone.

The TASER X26 CEW satisfies the International and UL electric fence standards by a wide margin and can be thus deemed very safe.

H. Comparison to General International Safety Standards

The IEC has set 40 mA AC as a safe level of utility (50/60 Hz) electrical current for avoiding the risk of VF induction (electrocution).[18,116] Rapid short-pulse stimulation has the same risk of VF induction as does utility power frequencies at a current of 9 times higher than the average current of the rapid pulses. The *TASER X26E CEW* delivers about 18 pulses per second at a charge of about 100 μC (microcoulombs) per pulse.[40] This gives an average current of 1.8 mA which corresponds to a utility power current of 16 mA. This is seen to be less than 1/2 of the IEC VF safety level.

The TASER X2 and X26P CEWs delivers about 19 pulses per second at a charge of about 63 μC (microcoulombs) per pulse.[40] This gives an average current of 1.18 mA which corresponds to a utility power current of 10.6mA = 1.18 mA • 9. This is seen to be less than 1/4 of the IEC VF safety level. The TASER X26E, X2, and X26P CEWs satisfy all relevant international electrical safety standards.[15,219]

The available TASER CEWs satisfy all relevant electrical safety standards.

I. Electricity Does Not Build Up Like Poison: Baseball vs. Science

It is often alleged that multiple CEW applications are somehow more dangerous than a single standard 5-second CEW application. This can seem to be very intuitively appealing as multiple baton strikes and multiple bullet wounds are more dangerous than single ones. This intuition is, however, completely wrong and contrary to decades of scientific research. Due to the prevalence of this false intuition — even among some clinicians and pathologists — it is helpful to present a fairly lengthy discussion of the scientific facts below.

In fact, 1 second is the official implied value used by UL for their electrical safety standards. [121] The IEC uses a more gradual transition out to about 3 seconds as seen in Figure 40. Note that the UL has a slightly stricter safety limit for VF than does the IEC but that is not relevant to this discussion.

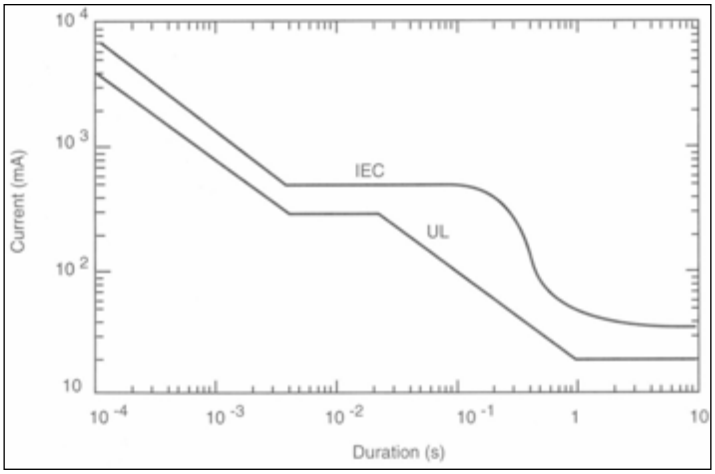

Figure 40. UL and IEC standards recognize that VF is induced or not within 1-5 seconds.

These standards are supported by numerous animal and human studies. The "transition time" is the number of seconds after which VF is either induced or not induced with a certain level of electrical current. A summary of studies of the transition time is given in Table 19.

Table 19. VF transition times from various studies

Author	Model	Transition Time (seconds)
Antoni[111]	guinea pig	0.8
Wegria[112]	exposed dog hearts	0.2
Ferris[113]	sheep	1.4
Jacobsen[114]	swine	4.0
Roy[115]	dog	2.0
Scott[119]	dog	< 3.0
Kiselev[120]	dog	< 5.0

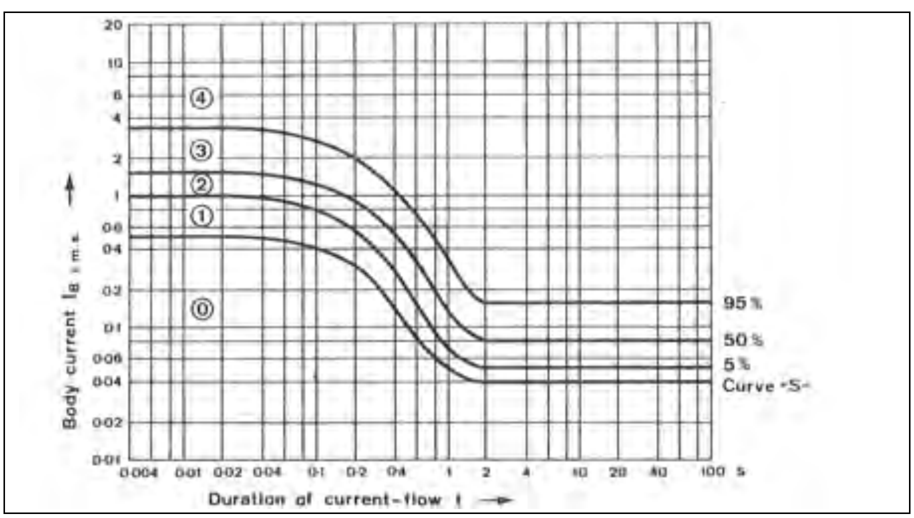

Figure 41. Original Biegelmeier curves showing safe (S) currents for humans.

Using calculations based on the human heart rate, Biegelmeir and Lee determined that the transition time for humans is 2-5 seconds.[116,117] See Figure 41. In a human study, Swerdlow et al showed that the VFT decreased by 47% with durations going from 1-5 seconds, consistent with the calculations of Biegelmeier.[118]

In a canine study, Scott et al found that the VFT did not change with durations going from 3 out to 60 seconds.[119] Kiselev also found the VFT to be quite constant from 5 to 30 seconds.[120] Scott states in his conclusions:

> Shocks of 3, 10, 30, and 60 seconds duration produced very similar mean [VFT] values. The stability of mean [VFT] over this wide range of shock duration suggests a basal threshold of fibrillation. Currents below this threshold seem unable to induce fibrillation regardless of shock duration.[119]

Scott's study showed that nothing happens between 3 and 60-second applications of current. Importantly he did this study in 16 canines, which have hearts that are electrically similar to humans — unlike pigs.[220-224]

The Dogma Of 3 Strikes And 15 Seconds.

While anesthetized animals have been tested up to 30 minutes, human CEW testing has to be performed on volunteers. Law-enforcement trainees are often required to take a 5-second CEW exposure but it is very difficult to find volunteers willing to expose themselves to more than 10 or 15 seconds. Therefore, most clinical trials of the physiological effects of the TASER CEW, involve exposures of 5, 10, or 15 seconds. For example, there are a number of studies with continuous 15-second exposures.[225-228]

The independent review of Pasquier found:

> According to the available results, the physiologic changes from electronic control device exposure appear to be safe in healthy individuals who undergo an exposure duration of 5 to 15 seconds, i.e., the duration that corresponds to the majority of field exposures."[229]

Importantly, these clinical studies failed to find any trends for increased effects between 5, 10, and 15 seconds so there has been no evidence to motivate longer-duration studies. Dawes observed, "... the duration of the exposure does not appear to have a significant effect on CK [creatine kinase]."[230]

There is certainly a false lay-intuition that electrical charge must build up like poison since baton strikes and bullet wounds do tend to injure in a cumulative fashion. However, over 100 years of electrical research has demonstrated that the direct effects of electricity do not build up like poison. Specifically, the US military has tested this in swine with continuous CEW exposures across the whole chest up to 30 minutes — not 30 seconds.[231] If someone is electrocuted this generally occurs within 1 second with an upper limit of about 2-5 seconds.[116,117] If an electrical current is strong enough to kill someone it will do so

in the first few seconds of exposure and a longer exposure duration simply has no additional effect. With a full-trunk human exposure, there is a slight pH shift (blood becomes less alkaline) in the first few seconds but then does not change.[133,135,138,139,232-236] For a given degree of subject resistance, the more the CEW is used, the better the outcome will tend to be since the use of more conventional force control options can be reduced. [12,237-241]

The epidemiological data unambiguously finds no increased risk with CEW exposures beyond 15 seconds:

1. Brewer studied 292 arrest-related-deaths (ARDs) where a CEW had been used.[90] He found that: (1) over 75% of the 292 deaths involved only 1 or 2 CEW exposures, (2) 85% of fatalities were preceded by 3 CEW exposures or less, and (3) concluded that there was no correlation between the number of CEW exposures and the mortality rate.

2. White studied 188 ARDs where a CEW had been used and similarly found that 87% of them had 3 trigger pulls or less which is the equivalent of 15 seconds of discharge or less.[242]

The widespread dogmatic urban myth that 15 seconds is safe while 16 seconds is dangerous is contradicted by all of the relevant scientific studies and statistics.

Electrocution takes 1-5 seconds.

J. The Handheld CEW Has Led to Dramatic Reductions in Injury.

Numerous published studies have now clearly demonstrated substantial injury and fatality reductions from the use of TASER CEWs compared to alternative control techniques.[12,243-249]

A partial list of these studies includes:

1. Bozeman comparison to other force options, including physical force.
2. MacDonald which compared the CEW to pepper spray and "physical force."[12]
3. Taylor which compared the CEW to pepper spray, baton strikes, and "hands-on."[13]
4. Mesloh who studied CEW usage in comparison to many control options.[238,245]
   a. Gentle hold
   b. Handcuff
   c. Leg restraints
   d. Pepper spray
   e. Compliance holds
   f. Takedown
   g. Empty hand strike

h. FN303/Pepperball
i. Impact weapon
j. Canine

The largest epidemiological study was the 2009 MacDonald study of 24,380 uses of force.[12] This study found that CEW usage dramatically reduced both subject and officer injury (by 2/3) compared to alternative force options. Additional studies demonstrating injury reduction are memorialized in the papers of Taylor (13,983 subjects)[13], Mesloh (n = 4303)[245], Smith (n = 1645)[239], Butler (n = 562)[240], White (n = 243)[176], and Bozeman (n = 893).[249]

On average, the use of the CEW reduces subject injuries by about 2/3. To put it another way, the use of alternative control techniques triples (3x) the risk of injury to subjects. Fatal suspect shootings are also reduced by 2/3 when electronic control is used without excessive restriction. [91]

a. The deployment and use of TASER CEWs has been shown to reduce injuries to officers and subjects over other force options, including physical force.[12]
b. The deployment and use of TASER CEWs has been shown to reduce use-of-force civilian complaints and law enforcement internal affairs complaints against law enforcement officers.[250]
c. The deployment and use of TASER CEWs has resulted in the reduced need to use deadly force.[89,91]
d. Rates of injury from TASER CEWs is less than several other common law enforcement force options, including, but not limited to: physical force, chemical aerosols, batons, impact tools, canines, rubber bullets, and bean bags.
e. TASER CEWs are a safer alternative than other comparable law enforcement force options tools or techniques.
f. TASER CEWs are shown to reduce subject injuries when compared to physical force options.
g. TASER CEWs have greater accountability features than any other force option.
h. TASER CEWs are the most studied force option available to law enforcement.
i. TASER CEWs are the most effective force option in gaining compliance without need for deployment or application (up to 81%).[251]

The TASER CEW reduces subject injuries and fatalities.

General Comments

Previous Testimony

I have testified as an expert at trial or by deposition within the preceding 4 years in:

1. Patent Inter-Party Review of Nevro v Boston Scientific re US #6895280, Wash. DC. US Patent Appeals Board. (Apr 2018) P
2. Patent Inter-Party Review of Nevro v Boston Scientific re US #7587241, Wash. DC. US Patent Appeals Board. (Apr 2018) P
3. Wrongful death case of Aguilar v Los Angeles PD. US District Court, Los Angeles, CA. (May 2018 and May 2019) D
4. Wrongful death case of Ramos v East Hartford, CT. US District Court, Hartford, CT. (June 2018) D
5. Wrongful death case of Todero v Greenwood, IN. US District Court, Indianapolis, IN (Sept 2018) D
6. Wrongful death case of Silva (Haleck) v Honolulu, HI. US District Court, Honolulu. (May 2019) D
7. Wrongful death case of Wood v Entergy. Arkansas District Court, AR. (May 2019) P
8. Patent case of Cardionet v Infobionics. US District Court, Boston, Massachusetts. (Sept 2019) D
9. Labor arbitration of Payne v Omaha, NE. US Dept of Labor (Oct 2019) P
10. Wrongful death case of Timpa v Dallas, TX. US District Court, Dallas, TX (Dec 2019) D
11. Criminal case of USA vs. Burton Ritchie. US District Court, Las Vegas, NV (Jan 2020) P
12. Starke v Astar et al. Florida District Court, St. John's County, FL (Apr 2020) D
13. Patent Inter-Party Review of Nevro v Boston Scientific re US #9162071, Wash. DC. US Patent Appeals Board. (Apr 2020) P
14. Patent Inter-Party Review of Nevro v Boston Scientific re US #8682447, Wash. DC. US Patent Appeals Board. (Apr 2020) P
15. Patent Inter-Party Review of Nevro v Boston Scientific re US #6381496, Wash. DC. US Patent Appeals Board. (Apr 2020) P
16. Loftis v American Electric Power. US District Court, Charleston, WV (Oct 2020) D
17. Valear v Xcel Energy. Colorado Dst Ct., Denver Cty, CO. (June 2021) D.

Fees:

My fees for this expert consultant report are $480 per hour for the research and preparation, plus expense reimbursement. My fees for testimony (at trial or

deposition) are $480 per hour plus anticipated expense reimbursement and are due prior to the commencement of a deposition. Fees for travel are portal-to-portal and are $240 per hour when not performing work billable at $480 per hour.

Right To Amend:

The opinions in this report are living opinions. Should additional discovery material be received, or additional research be completed, and then reviewed, these opinions may be altered or reinforced depending upon what information is obtained, reviewed, or studied. If new issues are opined, identified, or developed subsequent to submission of this report, I reserve the right to supplement, or further supplement, this report. *I especially reserve the right to amend my report after receiving new forensic evidence.*

Further Development:

Further, the opinions, which are expressed in this report, are listed to comply with current report requests. Each opinion may be further developed through research, investigation, during deposition or trial testimony.

Specific References:

Some of the opinions in this report may list specific references to some of the case specific documents reviewed or considered. These listings are not intended to be all-inclusive. I specifically reserve the right to supplement the support for each of the opinions in this report.

Opinion Methodology:

The enclosed opinions were developed using the disciplines of bioelectricity, electrophysiology, biomedical science, cardiovascular physiology, scientific methods, mathematics, and physics and are to a reasonable degree of professional and scientific certainty.

Additionally, the opinions provided in this case were developed using one or more qualitative and quantitative research methodologies, in addition to my education, training, experience, and literature review.

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